INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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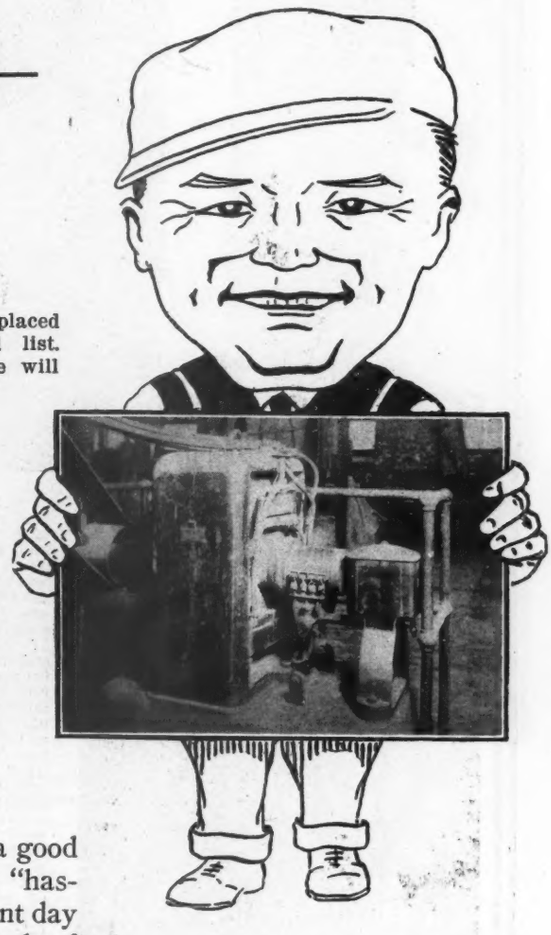
Here's an Old One–

And Loud Evidence of What a Good Motor Will Do



THAT picture in our last issue of a motor that had operated four years and eleven months without a complaint has started something. It called forth the interesting photo of an "old timer" which I hold here and this comment from C. E. Winchell, Sales Manager for the Triumph Electric Company:

Being an old-timer like yourself, I am much interested in your letter on page 411 of INDUSTRIAL ENGINEER for September, 1922, and could not resist the temptation to come back at you with a little information in regard to one of our old-time motors, which may prove interesting.

The photograph I am sending herewith is of a TRIUMPH old-type iron-clad, cast-iron frame, bipolar machine, built about 1892 or 1893, one of the first that we ever built.

This motor has been running every day, except Sundays, since that date, and is still in every-day operation in the plant of the Wm. S. Merrill Company of Cincinnati, where it has been operating continuously since it was originally purchased in the year mentioned.

So far as we know, nothing has ever been done to this motor except to renew the carbon brushes and the oil in the bearings. This makes about thirty years of active service and may go a little way toward answering your question as to how old a motor must be to be positively and undeniably placed on the honorably retired list.

I feel sure that someone will dig up a motor older than this one and will watch for his notice with much interest.

Now then, the peg is raised—thirty years of active service without repairs is a real record and it is loud evidence of what a good motor will do. But are you going to let Mr. Winchell get away with this oldest "old timer" still at work? Let's get up a good long list of the near "has-beens" to show the present day "isers" what is expected of them as to age limit in service.

It's in order, I think, to suggest that Mr. Winchell should capture that 1892 motor for his own or some national museum and put a younger one in its place for his grandchildren to visit and interview on its service record in 1952.

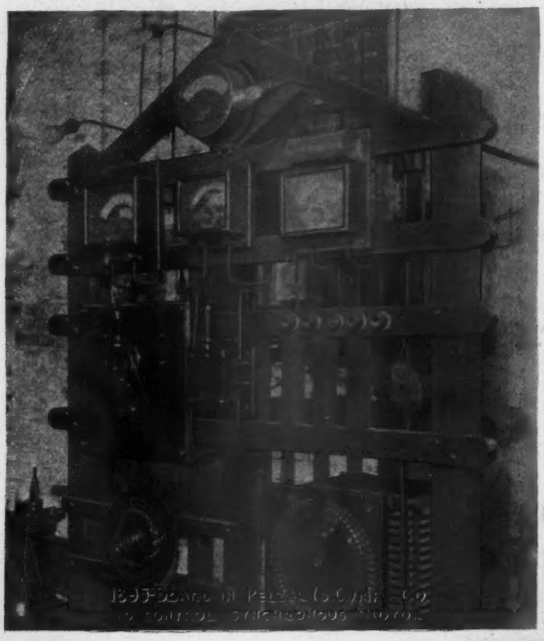
Practical Pete

P. S.—By the way, read what Mr. Mulford has to say on page 507 concerning Mr. Nickel's installation shown on this page of our August issue. Mr. Mulford is one of those (still young) men who helped to start the electrical business and the things he says reflects the thinking of one who doesn't have to guess but draws on a full storehouse of experience.

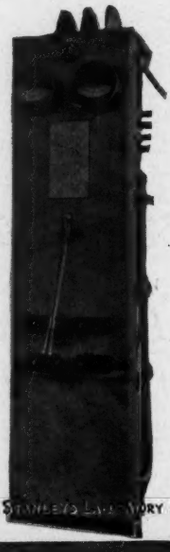
Old and Modern Switchboards

Designs in Use Between 1890 and 1922

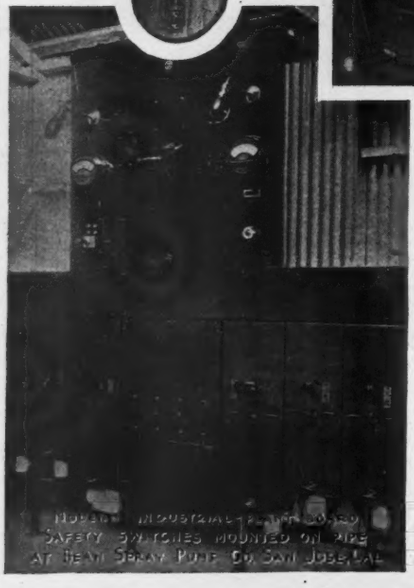
1890-GENERATOR SWITCHBOARD



1893-BOARD IN POWER CO. FOR CONTROL SYNCHRONOUS MOTOR

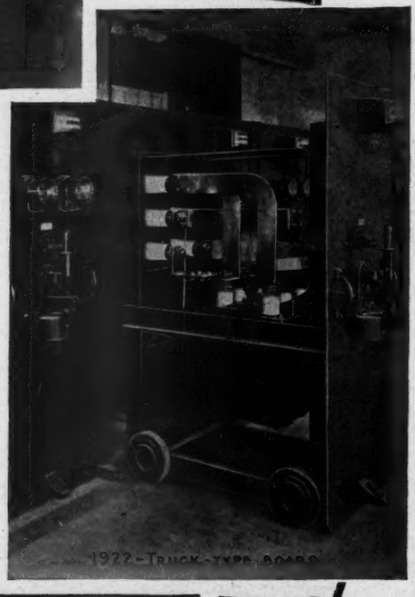


USED IN WM. STANLEY'S LABORATORY ABOUT 1895

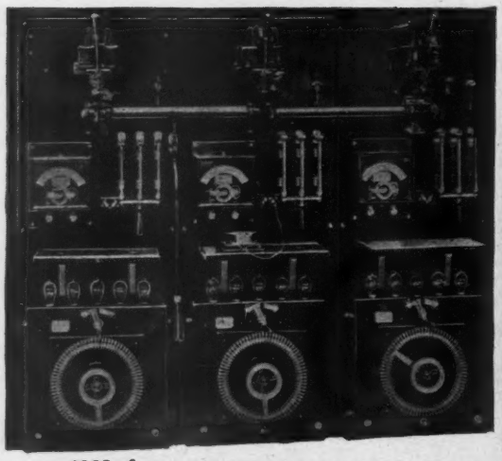


MODERN INDUSTRIAL PLANT BOARD SAFETY SWITCHES MOUNTED ON PIPE AT HEAT SPRAY PUMP CO. SAN JOSE, CAL.

SOME early boards were merely wooden frames supporting the switches, meters and rheostats. Wiring and live parts were exposed. Gradually more of the equipment was placed back of the board and operated from the front by insulating handles. Solid panels of marble and slate were later substituted for the wooden frames. Lately asbestos compositions have been used. As switches grew larger remote electrical control replaced manual control and resulted in the bench board, with control handles for many switches in a small space. The truck-type panel is a modern design which makes adjusting and repairing safer. The equipment and wiring is mounted on a section which may be pulled out of contact with live parts. Boards made of safety switches mounted on pipe framework have lately come into favor, especially in industrial plants.

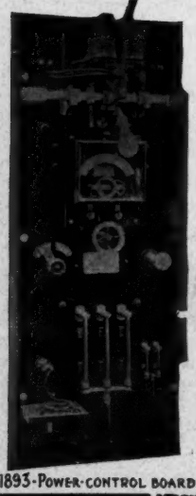


1922-TRUCK-TYPE BOARD



1893-GENERATOR-CONTROL BOARD

1922 HELL GATE STATION GENERATOR AND FEEDER BOARDS



1893-POWER-CONTROL BOARD

IN THIS ARTICLE details of power service are given that have been worked out to meet the requirements of production processes from the standpoint of continuity of service and the inter-dependence of one machine on the next in a series of operations and also to provide motor equipment and control that can be satisfactorily operated by common labor. A complete equipment of individual motor circuit breakers is a feature of the installation together with the distribution arrangements in providing light and power service throughout the works.

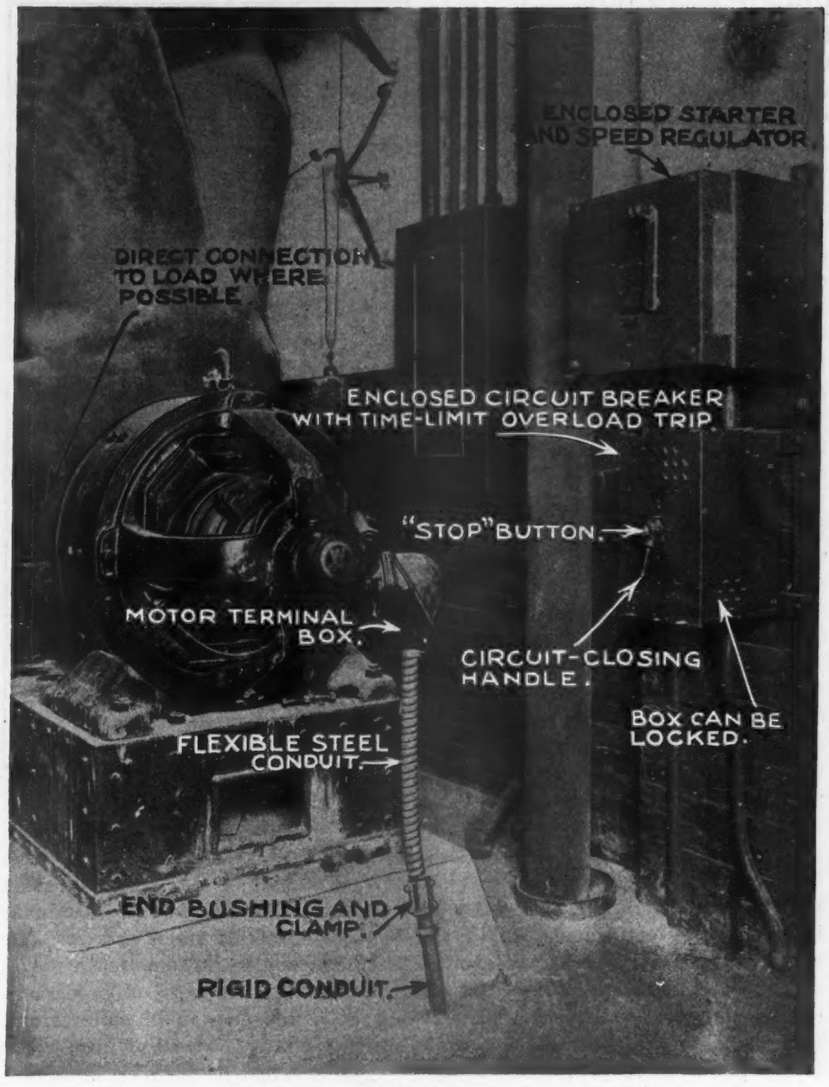
Some Ways of

Decreasing Production Interruptions

By the Use of Proper Distribution, Protection and Control Equipment

By ROGER B. STEVENS

Formerly Electrical Engineer of Consulting Board, American Sugar Refining Company, Baltimore, Md



A typical motor, starter and circuit-breaker installation in the plant of the American Sugar Refining Company, Baltimore, Md.

RELIABILITY and safety are the qualities which have been worked out to a high degree in the distribution, control and motor equipment of the plant of the American Sugar Refining Company, at Baltimore, Md. Among the conditions which had to be met were the low grade of labor used in a sugar refinery, the danger of material being damaged by extensive shutdowns, danger of stoppage of one machine in a chain of several where the material should flow continuously from one to the next, provision for a future 25 per cent increase in cable capacity and provision for possible speed changes required in driven machines. Among the features which stand out in meeting these conditions and others, are the use of lead-covered and asbestos-insulated wire and cable wherever there is the slightest chance of moisture or excessive temperature, the protection of all conductors and live parts by conduit and steel cabinets and covers and the installation of individual motor circuit breakers with the attendant elimination of fuses from the power circuits. Each machine as a rule has its own separate motor. In the entire plant there are approximately 500 motors aggregating some 7,000 hp., the largest being of 300 hp. These are direct-current 230-volt motors.

Motors Chosen With View to Changing Speed Later

On account of the high starting torque required by much of the machinery, and of the desirability of providing adjustable-speed drives for many of the processes, direct-current motors were chosen. In almost all cases, the connection between motors and driven equipment was made by means of spur or worm gears, silent chains or by direct application to the driven shafts. Motor speeds in most cases range from 750 to 900 r.p.m.

In order to take advantage to the fullest extent of the adjustable-speed possibilities of the direct-current shunt- or compound-wound motor, through the use of shunt-field rheostats, every drive in the plant where there was the slightest possibility of future requirement for a change in speed has been provided with a motor whose normal full-field speed is somewhat lower than the expected requirement. The normal speed required under present conditions, or any higher or lower speed which may be desireable in the future, due to changed conditions, may thus be achieved through the use or manipu-

lation of shunt-field rheostats. It is thus possible to obtain, without the use of the inefficient series rheostat control, any speed from about (for shunt motors) 25 per cent below the expected normal to 75 per cent above it, or (for compound-wound motors) 5 per cent below to 10 per cent above. The motors used are so designed that practically perfect commutation is procured up to 100 per cent above normal full-field speed in the case of shunt-wound, and up to 15 per cent above full-field speed in the case of compound-wound motors. This allows for almost any possible future requirement within the power of the motor to be met without the necessity for changing motors. In order to prevent overspeeding of the equipment by unskilled or uninstructed operators where adjustable field rheostats were installed, the amount of field resistance proper for the highest speed required under present conditions was determined as soon as the plant started to work sugar. The excess resistance was then shunted out with an easily removable soldered jumper.

Every motor in the plant has been equipped with some form of conduit terminal box which allows the cable to enter the motor frame without breaking the continuous chain of conduit protection. A standard system of entering the terminal box on the motor was determined upon and used in practically all cases. This is well shown in several of the equipment pictures. The rigid conduit terminates just above the floor or, in the case of motors on suspended or elevated mounting, at the motor base. It is equipped with an end bushing and clamp and the final run of 18 in. to 3 ft. is made in flexible metal conduit of the Greenfield type which enters directly into the cast-iron or steel box on the motor frame. Connections to motor circuit breakers and control devices are made by carrying the conduit into the steel case, with a locknut and bushing.

All manual starters and field rheostats of the face-plate type are equipped with safety covers which entirely obviate the possibility of accidental contact with live metal parts, only the insulating operating handles projecting through the covers. Automatic and remote-control equipment, where used, is installed in steel cabinets with provision for locking while in service.

The motor protection and control equipment was chosen after careful consideration of operating and process conditions of a sugar plant. Among these conditions are: (1) A low grade of labor; (2) necessity to prevent shut-downs to eliminate spoiling material under process; (3) interdependence of one machine on the next in a series of processes; (4) possible change in material requiring changed speed of machine.

The greatest problem encountered, from the standpoint of protection of apparatus and product, was the nature of the labor used. A large part of the work is done with common laborers operating machines, and a great deal of foreign and colored labor is employed, so that equipment which requires a high degree of skill and care in its operation would be decidedly out of place. Added to this is the inherent high labor turnover which makes it essential that equipment be provided which green labor can be trained to operate in the minimum of time. At first glance, this condition would seem to point to the desirability of providing automatic control of electrical equipment wherever possible. However, maintenance of an extensive equipment of automatic devices requires a comparatively large force of high-priced men. Even with the best of care, unless a sufficiently large stock of spares is maintained and routine replacements are made before trouble develops, short-time shut-downs for adjustment and minor repairs are bound to occur.

After full deliberation, the decision was made that the cheapest and most reliable operation was to be obtained from rugged, manually operated equipment where its use was possible, fitted with every suitable safety device and protective appliance to prevent accident and destruction of equipment. Where automatic equipment was required, either because of the nature of the operation or because remote control was necessary, every precaution was taken to have it as simple as possible in operation and construction and to protect it in every way from mechanical or electrical injury.

Probably the greatest single step toward the attainment of the ideal

AMONG THE OPERATING conditions which had to be met in the plant of the American Sugar Refining Company at Baltimore, Md., are the following:

(1) Low-grade labor necessitating easily operated equipment.
(2) Necessity for preventing long shut-downs which would cause tremendous loss by spoilage of material in process.
(3) Chains of machines operated in sequence on continuously moving material. The arrangement must be such that a shut-down of one machine will stop other machines ahead of it to prevent piling up of material at the shut-down machine.
(4) Variable condition of product requiring variable motor speeds.
(5) Provision for future increase of plant capacity.
(6) Safety to men and machines.
(7) Heat and moisture.

In this article details are given showing how these conditions were met in the motor control and protection, and in the distribution system.

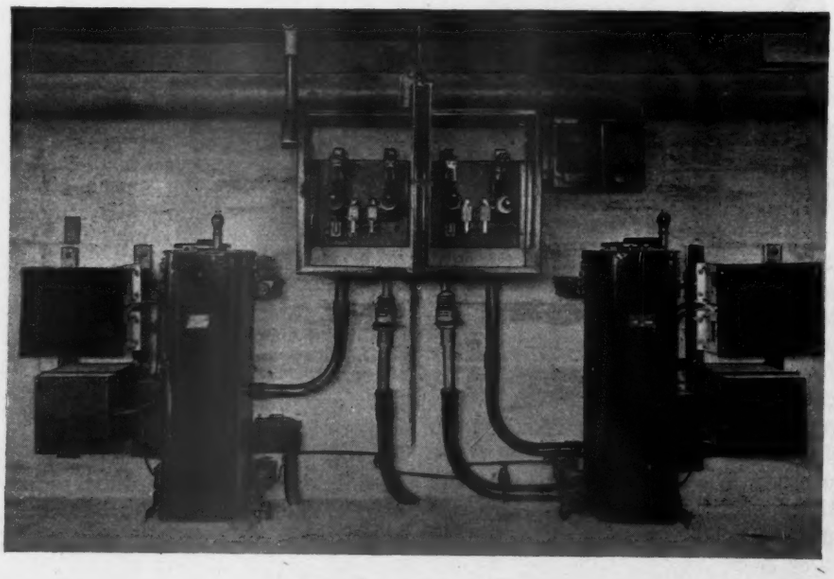


Fig. 1—Breakers, drum controllers and resistors for 75-hp. motors driving molasses and syrup pumps.

installation entirely free from the usual periodic shut-downs is represented by the installation of a complete equipment of individual motor circuit breakers and the attendant complete elimination of the troublesome and expensive fuse from the power circuits. The writer believes that, of all the causes of lost time in electrified industrial plants, the greatest is the fuse. Especially is this true in the modern factory where material is routed through a series of machines or processes in a continuous sequence of operations, each dependent for its operation upon the proper and complete functioning of the units immediately preceding and succeeding it in the chain.

The blowing of a fuse means that an electrician must first be sent for. He must determine the size of fuse required, obtain it from the store room, and then return and install it. In the usual type of modern works this means a loss which is easily determinable with accuracy as to extent. It amounts to an astounding figure when proper account is taken of the time lost by the machine directly affected and its operator, the machines immediately following it in the process sequence and their operators, and the machines preceding it in the process which must be stopped or slowed down to prevent the piling up of material in an unstable, partly manufactured condition. In the case of a sugar refinery from the time the raw sugar is first dumped from the original bags until it assumes the form in which it reaches the sugar bowl, it is almost continuously in a condition which allows it to be left for only a very few minutes without serious deterioration. A striking illustration of the possible amount of loss is seen in the case of the mixers under the vacuum pans. These mixers are great tanks with agitators, which receive the sugar from the pans after it has been boiled down and crystallized and keep it in a constant state of agitation until it can be put through the centrifugal machines to separate the crystals from the syrup with which they are mingled. Each mixer may hold at one time as much as 80,000 lb. of mixture. Should the agitators stop for any considerable length of time, the whole batch hardens and must be dissolved out with hot water and put through practically the whole refining process again. During the period while the mixer is being emptied and cleaned —a matter of hours—the battery of from four to eight centrifugal machines which depend upon it for their supply of raw material are rendered idle, with their operators.

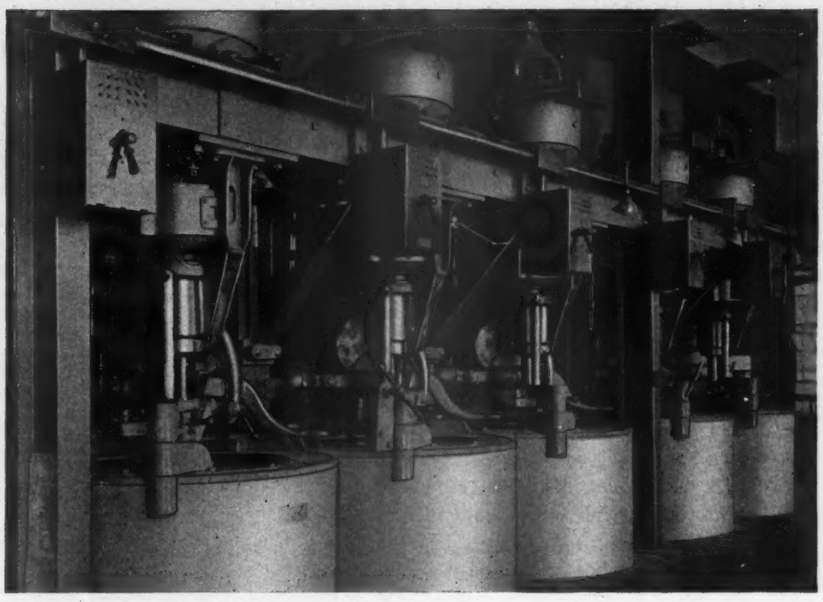


Fig. 2—Typical individual motors and breakers on centrifugals in pan house.

Realizing the cost of delays it is natural for the electrician in charge to put in a heavier fuse, if fuses are employed for protection. Or the man operating the machine may achieve a very original idea and jumper the fuse block with a piece of No. 4 copper wire, on the back, where it can't be seen. Then the trouble stops—until a real overload comes along, after which a new motor is installed, while the old one is sent to the shop for the rather expensive job of rewinding.

These dangers were appreciated to such an extent that figures were compiled which proved conclusively that the installation of a circuit breaker would pay for itself in a surprisingly short time, provided it could be properly protected from unauthorized tampering, and at the same time left available for easy and quick operation. Such a breaker was placed on the market at just about the time the designs for the Baltimore refinery were getting under way, by the Cutter Company. It

Fig. 3—Cabinets for eleven feeder breakers on one floor.
Each breaker has its hinged door and entire front of cabinet may be removed. Breakers are separated by barriers. These breakers are rated at 500 and 600 amp. and each feeder supplies six or eight centrifugals.

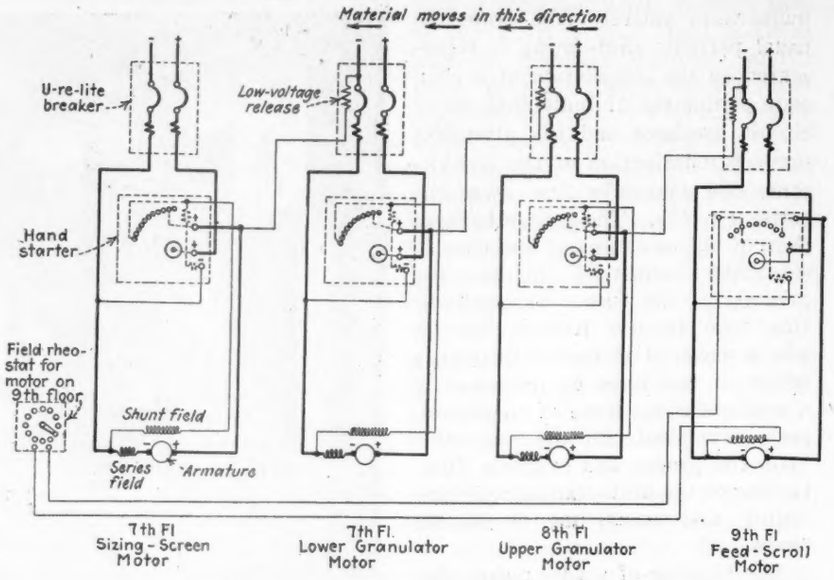


Fig. 4—Arrangement to prevent spoilage when one machine in a series stops.

This shows the wiring connections of four machines which represent four steps in a continuous process. If one machine stops, the machines ahead of it in the train will also stop, so that material will cease to flow to the faulty machine. The machines behind the defective one continue to operate and will eventually empty themselves. This interlocking is accomplished by connecting the low-voltage release of each machine to the armature circuit of the next machine. Voltage failure on any machine will thus trip out the preceding machine. The same principle has been applied to automatic controllers where they are employed.

consists of a circuit breaker installed in a steel box, which is built in two parts, much in the manner of the distributing cabinets described earlier in this article. In fact, the idea for those cabinets was taken from the breaker box. This allows easy and convenient conduit wiring. The breaker is operated by an insulated handle mounted on the outside of the box. The construction is such that after the breaker is closed the handle becomes independent of the breaker arms and may be carried to any position throughout the operating range and fastened, without interfering with the overload operation of the arms. This does away with one serious objection to the use of breakers on individual motors, as with the ordinary type it is easy enough to block or tie the operating handles in such a way as to prevent opening under overload. The instrument is so arranged as to be non-closeable on overload, and is arranged with a direct-acting time-limit device to take care of starting overloads. The box may be locked to prevent tampering with the adjustments and the breaker arms may be locked out to allow repairs to be made on the circuit with safety. Several of the photographs appended show the application of these devices. A feature of this particular breaker which made it especially well adapted to the requirements of the present installation is the fact that no external overload relays are used. An overload device acts directly on the tripping mechanism instead of an auxiliary control circuit. This simplifies the mechanism very considerably, and assures positive and dependable operation.

When one of these motor breakers opens from any cause, the operator of the machine himself attempts to close it. If the trouble is due to a persistent cause, such as an insulation breakdown and consequent short circuit, the breaker fails to close and the operator sends for assistance. If, however, as is much more frequently the case, the trouble was caused by a momentary overload due to starting or to a non-electrical cause (such as a jammed machine) which the operator can remove, the breaker goes in and stays at the first or second attempt, and the operation proceeds without serious delay.

For the purpose of determining the method of protection to be applied, all motors in the plant were divided into three arbitrary classes,

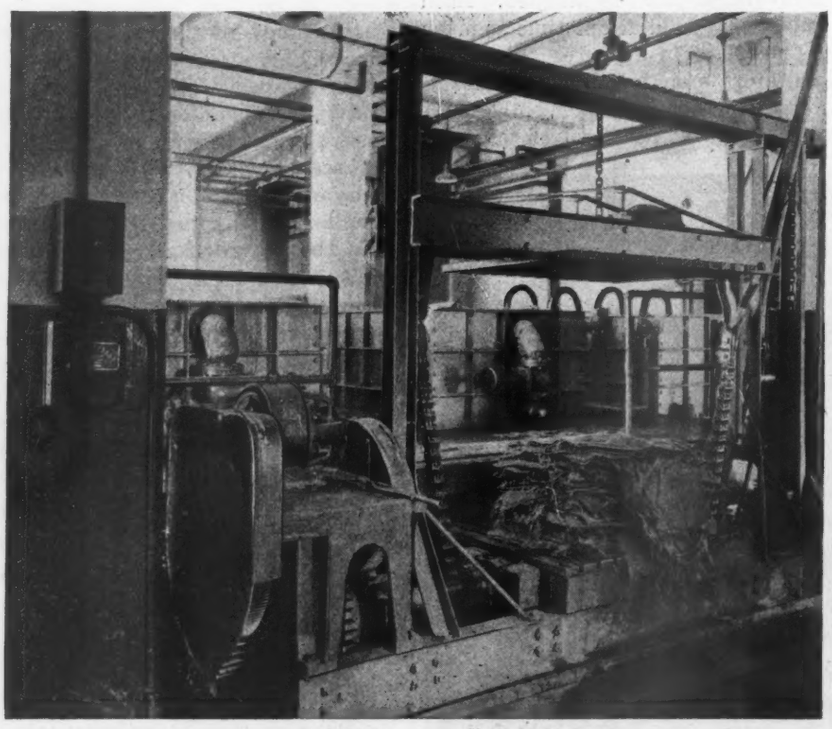


Fig. 5—The circuit breaker on this bag press trips when proper pressure is reached.

This is an unusual use for a circuit breaker. An automatic controller with pressure-operated trip would ordinarily be recommended for this application. However, the arrangement shown was installed because the machine was needed for immediate use and the time was too short to make the necessary changes. The motor is geared directly to the press and the pressure applied is limited by the circuit-breaker setting. The breaker is ordinarily set to open when the motor is loaded about 100 per cent above its normal 40-deg. continuous rating. The motor was chosen for a cycle of duty every half hour. The cycle is such that the root-mean-square load on the motor under the worst conditions met at present is only about 75 per cent of the rated continuous load.

The breaker is designed for normal operation at its present setting. Operation has been very satisfactory and no trouble is anticipated due to repeated opening of the breaker under this load.

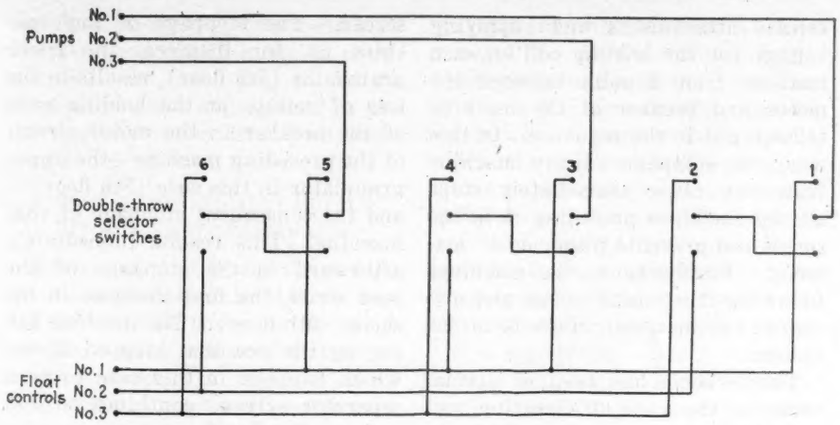


Fig. 6—Switch connections to transfer pumps to different float controls.
By throwing the six switches up and down according to the accompanying table, any float may be made to control any pump. The single lines in this diagram really represent eleven conductors and the selector switches are eleven-pole, double-throw knife switches. Each float control has eleven points and the eleven wires at the motor panel are connected to an automatic starter and ten-point speed regulator. The switch positions for obtaining any desired pump combination are as follows:

PUMP COMBINATION DESIRED		SWITCH POSITIONS					
Pump	Control	1	2	3	4	5	6
1	1						
2	2	up	open	down	down	down	up
3	3						
1	2						
2	3	down	down	down	up	up	open
3	1						
1	3						
2	1	down	up	up	open	down	down
3	2						

depending on their application, size and method of control, as follows: (1) Motors of 50 hp. and below, with manual starters; (2) motors of more than 50 hp. with manual starters, and (3) motors of any size with automatic starters.

Motors of Class 1 are in every case equipped with the standard type of fully enclosed breaker which was just described. This class includes most of the motors in the plant. It was found, however, that the cost of the completely enclosed, externally operated type of breakers in capacities above 250 amp. was excessively high. For this reason, motors of the second class were provided with I-T-E type W breakers, installed in cabinets identical with those throughout the distributing system and already described. The only difference between the motor and distributing-circuit breakers is that the motor breakers in all cases were provided with time-limit devices to take care of starting overloads.

The feeder breakers were so equipped only when the largest motor on the circuit to be protected might be expected to take a starting current of a magnitude comparable with the current value at which the feeder breaker would be set. In most cases where motors of this class have been installed, the motor breaker and its cabinet have been grouped with those protecting the branch feeders on the same floor, with a separate feeder from the breaker group to individual motor.

Motors of Class 3 required careful consideration. The grounded-neutral lighting system in the plant necessitated the use of two-coil protection on the overload device. The plan finally adopted was to purchase from the Westinghouse Company their standard Type C counter e.m.f controllers with special double-pole, double-coil overload relays and main-line contactors with time-limit attachment, and to dispense with the separate circuit breakers. Certain other manufacturers could have furnished starters with double-coil protection from their standard lines. However, as Westinghouse starters were used throughout in all other locations it was thought best to have the automatic starters of the same make for sake of standardization.

In a number of cases, as stated, where sugar or its derivatives is handled by a sequence of machines without storage facilities between, it is very important that if one of the machines stops, the machine ahead of it shall stop also to prevent the piling up of material and the flooding of the stopped machine. In

Fig. 7—Four portable winches unload ships along 700 ft. of docks.
These winches are connected to the plugs placed along the wall near each of the single-cargo booms. The winch is controlled from one of the cabs mounted high up on the wall. The cabs are at such a height that the operator can see on the deck of the ship, which eliminates the signaling required when the operator is at the level of the dock. There are seven of these cabs and four boom steps and plugs to each cab.

the older refineries this has been partly taken care of in a rather make-shift way by using the group-drive scheme, so that the failure of the prime mover of the group stops everything.

This method has several disadvantages, the outstanding ones being that, as the machines are ordinarily located on different floors in order to obtain a gravity flow of material, the use of belt drives through holes cut in the floors was necessary, and besides, when trouble occurred, the material remaining in the machines could not be run out because it was necessary to throw off belts or operate all including the machine which was out of order.

This has been effectively taken care of in this plant by providing the motor breakers with no-voltage release attachments and supplying voltage for the holding coil on each machine from a point between the motor and breaker of the machine following it in the sequence. In this way, the stoppage of any machine from any cause immediately stops all the machines preceding it in the series and prevents piling up of material. Furthermore, the machines following it continue to run and discharge the material which is in the system.

This scheme has been of special value in the case of elevating and conveying machines dumping into other machines. Fig. 7 shows the wiring diagram used in the case of such a system, where a group of four machines was protected. The machines are a feed scroll, an upper and a lower granulator and a sizing screen. The stoppage of any machine as, for instance, the lower granulator (7th floor), results in the loss of voltage at the holding coils of the breaker in the motor circuit of the preceding machine—the upper granulator in this case (8th floor)—and the consequent stoppage of that machine. This results immediately afterward in the stoppage of the feed scroll, the first machine in the series (9th floor). The machine following the one that stopped first—which happens in this case to be a separator screen—continues to run and empties itself.

This same principle was utilized on other hand starters and on automatic starters. On the automatic equipment the interlocking is done in the control circuits of the starters. The two schemes outlined, or

Power Feeder, Circuit-Breaker and Motor Data For Plant Having Over 450 D. C. Motors

The motors are direct-current and operated on 230 volts. The load figures are those determined in a preliminary estimate but except for slight differences they are correct today

BUILDINGS	CONNECTED LOAD				Demand Factor	LOAD DATA				CABLE SIZES								Circuit Breakers			Distance to Distribution Center, Feet	Voltage Drop, Per Cent
	Present		Ultimate			*Load, Kw.		Load, Amp.		Paper-insulated, lead-covered, in ducts				Varnished-cambric, double-braid, in conduit				No.				
	No. of Motors	Total H. P.	No. of Motors	Total H. P.		Present	Ultimate	Present	Ultimate	No. of Circuits, Present	No. of Circuits, Ultimate	Cables per Circuit in Each Leg	Size of Each Cable, Circ. Mils.	No. of Circuits, Present	No. of Circuits, Ultimate	Cables per Circuit in Each Leg	Size of Each Cable, Circ. Mils.	Present	Ultimate	Ampere Rating		
Pan and Finishing	134	1880	159	2608	0.60	1050	1463	4562	6370	3	4	2	1,300,000	3	4	2	750,000	3	4	1600	325	2.1
Adant Package, Syrup and Blackstrap	152	571	199	890	0.60	319	496	1389	2160	2	3	1	1,300,000	2	3	1	750,000	2	3	800	425	2.5
Filter	17	120	17	120	0.65	73	73	318	318	1	1	1	600,000	1	1	1	400,000	1	1	500	200	1.1
Shops	22	140	22	140	0.50	66	66	287	287	1	1	1	300,000	1	1	1	No. 0000	1	1	300	175	1.8
Boiler	34	1207	42	1547	0.60	685	865	2980	3760	2	2	2	1,500,000	2	2	2	1,500,000	2	2	2000	175	1.1
Coal Tower	7	285	7	285	0.50	135	135	586	586	1	1	2	1,500,000	1	1	2	1,500,000	1	1	2000	250	1.0
Power House	...	...	...	80	0.85	64	64	278	278	1	1	1	300,000	1	1	1	250,000	1	1	300	125	1.2
Salt-Water Pumps	3	900	4	1200	1.00	840	1120	3660	4480	3	4	2	1,300,000	3	4	2	750,000	3	4	1600	75	0.5
Lighting	...	†387	...	†427	0.80	310	342	1350	1489	1	1	2	1,300,000	1	1	2	750,000	1	1	1600	100	0.8
Raw-Sugar Shed	24	276	24	276	0.50	129	129	561	561	1	1	1	1,000,000	1	1	1	500,000	1	1	600	300	1.7
Cooperage	...	†250	...	†250	0.60	150	150	650	650	1	1	1	1,300,000	1	1	1	750,000	1	1	800	800	2.8
Wash House	59	986	69	1156	0.60	553	646	2400	2810	2	2	2	1,300,000	2	2	2	750,000	2	2	1600	200	1.1
Fire Pump	1	150	1	150	1.00	140	140	608	608	1	1	1	1,300,000	1	1	1	750,000	1	1	800	150	0.7
Totals	453	7354	544	8814	‡0.70	4514	5689	19629	24357	...	...	...	...	...	...	...	...	20	23	....	....	....

*The kilowatt load is obtained by taking the connected horsepower load, dividing by the demand factor, dividing by the motor efficiency (85 per cent) and multiplying by 110 per cent (to allow for additional starting load). †Kilowatts. ‡Average value.

modification of them, have been used wherever conditions made it desirable, with the result that one of the greatest troubles experienced by the existing refineries has been completely overcome.

Pumps Automatically Supply Widely Varying Demand

One of the most interesting of the control applications is that in connection with the three pumps which furnish cooling water for the jet condensers on the vacuum pans. Nine vacuum pans are used in the boiling operation, each pan requiring from none to over 1,500 gal. of water per minute. As the demand varies rapidly and the space available for storage tanks is small, a delicate control problem was involved. Almost all other refineries operate with steam reciprocating pumps, or with a combination of steam and electric pumps, and the control is almost invariably by hand. The control mechanism cannot usually maintain an exact balance between the supply and the demand. To make even a momentary shortage impossible, the control is set so as to give more flow than is required. As a consequence, large quantities of water (and power) are wasted in overflow.

In the present installation the amount of storage which could be provided without materially changing the design and cost of the building involved was only enough to run the plant for between two and three minutes. The demand, as nearly as could be calculated when the equipment was purchased, might vary anywhere between 3,000 and 13,000 gal. per minute, with the changes taking place almost instantaneously. This meant one of two things. Either the pumps must be kept running at all times at a sufficiently high discharge to supply the greatest possible demand, with a large amount of water going into the overflow during the time of less than maximum demand. Or else a system of control must be installed sufficiently sensitive and quick in operation to take care of the rapidly changing demand and maintain a good head of water in the tanks.

The problem was somewhat complicated by the fact that the water supply is taken from the Patapsco River at a point where there is a regular variation in the tide level from approximately plus 1 ft. to minus 1 ft. and a maximum to be provided against of plus 5 ft. to minus 4 ft. As the limiting height of the tanks was something less than 15 ft., it will be seen that the uncontrollable change in head against which the pumps must operate is nearly as great as the range through which it may be controlled by the level in the tanks. This made it impossible to use the head-delivery characteristic of the pumps to any great extent in maintaining control.

The equipment finally installed consists of three 12-in. DeLaval single-stage double-suction, volute centrifugal pump units, each direct-driven through shaft connection by a General Electric 300-hp. motor with a speed range of 850 to 975 r.p.m. and a pumping capacity of 3,000 to 6,500 gal. per minute at a total head of 140 ft. Floats are installed in the larger tank at three different levels, 4 ft., 8 ft. and 12 ft. from the bottom. These operate directly three eleven-point drum controllers by means of chains and counterweights. The motor control equipment, which was furnished by the Cutler-Hammer Manufacturing Company has a ten-point field-control panel for each motor arranged for full automatic starting and field control. The panel is operated by the drum controllers mentioned. Connection is made between each control panel and its drum controller by means of a fifteen-wire rubber-insulated, lead-covered cable.

Starting with full tanks and no pumps running, the operation of the control system is as follows: When a demand for water occurs due to the starting up of a pan, the level in the tanks drops until float No. 1 —the upper one—drops sufficiently to engage the first point on its controller. This closes the starting circuit of pump No. 1 and the motor comes up to its slow or full-field speed, delivering approximately 3,000 gal. per minute, more or less, depending upon the condition of the tide and the variations in the pump characteristic due to impellor wear, motor temperature, etc. Should this discharge be sufficient to take care of the demand, the tank level is maintained and the pump continues to operate at its slow speed. Should the demand be greater than the pump can supply at this speed, the float continues to drop and the drum cuts in the trip circuit of the first field-resistor contactor, which drops out, and allows the motor to speed up slightly. Resistance steps are added until either the pump discharge is equal to the demand on the tank system or the controller has cut in all ten field-control points of the No. 1 pump. Should the latter condition occur, any further drop in the tank level is accompanied by the cutting in successively of the starting and field-control points of the controller for the No. 2 pump and ultimately, of the No. 3 unit. The last condition will probably never occur except upon the failure of the No. 1 or No. 2 unit, as two pumps are designed to carry the full demand of the present plant, leaving the third for use as a spare. Provision is made for the installation of another similar unit when the capacity of the refinery is increased in the future.

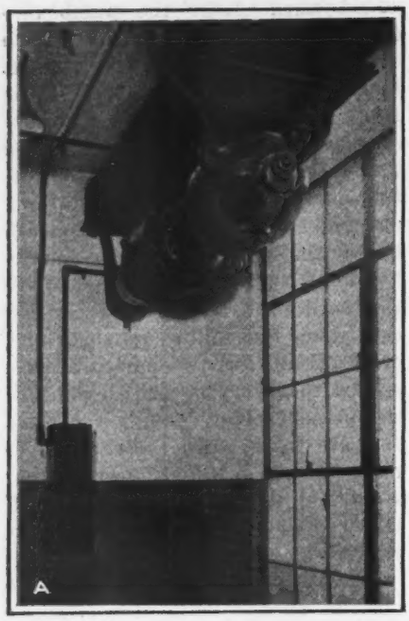
As the pumps operate against a positive suction head, it was necessary to install a priming system, in order that they might be ready at all times to pick up the load automatically without attention. This provision was made by the installation of two Nash rotary vacuum pumps connected to a common suction tank, which communicates with the suction pipes of the three units through float-operated priming valves.

It will be noted that the whole variation in the operation of each pump takes place with a variation in the water level of less than 4 ft. in the tank, from the point where the pump cuts in to the point where it is running at full speed and delivery.

When the demand on the tanks decreases, the operation of the control is the reverse of that described, the pumps successively slowing down and stopping either until a balance is again reached between pump discharge and volume of water used, or until the point is reached where there is no flow from the tanks, no pumps running, and the water level in the tanks is at its highest point. The equipment is then ready automatically to pick up the next demand.

Advantage of Making Pumps and Controls Interchangeable

Unless some means were provided for interchanging the pumps and controls, it will be seen that the No. 1 unit, which is the first to start and the last to stop in each cycle of operation, would wear out long before the No. 3 unit. In the original design, it was proposed to take care of this condition by periodically



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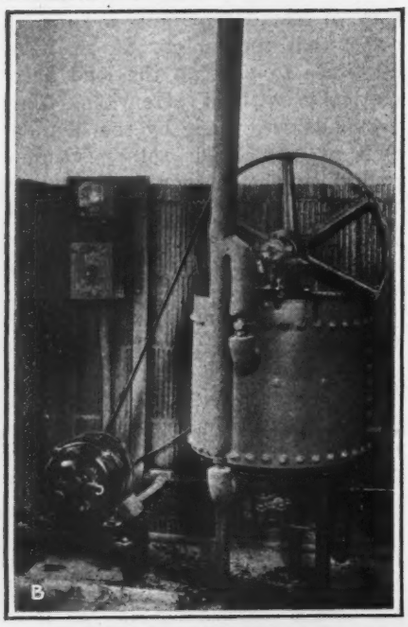


B

Examples of Motor
Protection and Control
in a Large Sugar Refinery

A—Manual control for motor driving powdered sugar machine on the other side of the wall. Power is transmitted between motor and machines through a Jones straight-line speed reducer.

B—This circuit breaker and starter are mounted directly above and control a motor which drives a glue mixer.

C—Here is a twenty-five horsepower motor direct-connected to a hot-air blower. The starter and circuit breaker are mounted, as shown, on a steel column close to the motor.

D—Motor connected by a Morse silent chain drive to a Sturtevant exhauster which removes the vapor from the bone-black dryers. The wall of the building provides a convenient support for the motor control.

E—This circuit breaker protects a row of plugs to which portable stacking machines are connected when in use.

F—This arrangement of circuit breaker and starter provides a convenient and safe control for a Forbes 4-in. pipe-threading machine.

G—Here is the Sturtevant blower and exhauster which serve the shop forges, with the control equipment mounted on the wall close by.

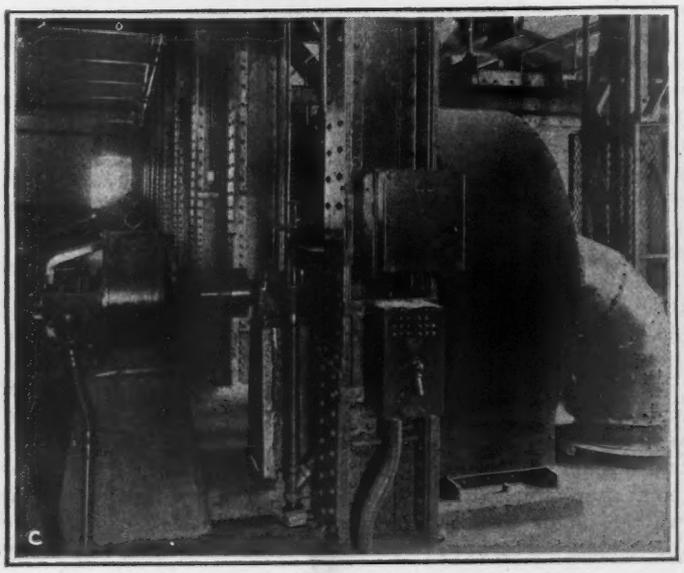
H—Accessibility features the wall-mounted control for this 1½-in. bolt cutter. Note the silent chain drive.

I—Mounting the circuit breaker on this circular saw saves time and steps for the operator when too deep a bite opens the breaker.

J—A typical starter and circuit-breaker arrangement on machine for cube and pressed-tablet sugar. In this case also, a building column provides a convenient mounting place.

K—The buttons at the left control distant motors while the breakers furnish protection for nearby motors. Buttons and breakers are mounted on a light iron framework.

L—Both a circuit breaker and automatic starter are used in this installation because the starter which was furnished with the machine had only single-coil protection on the main-line contactors, which does not give complete protection on a grounded-neutral circuit.



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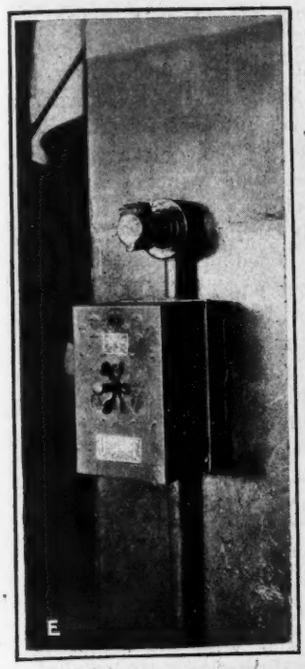
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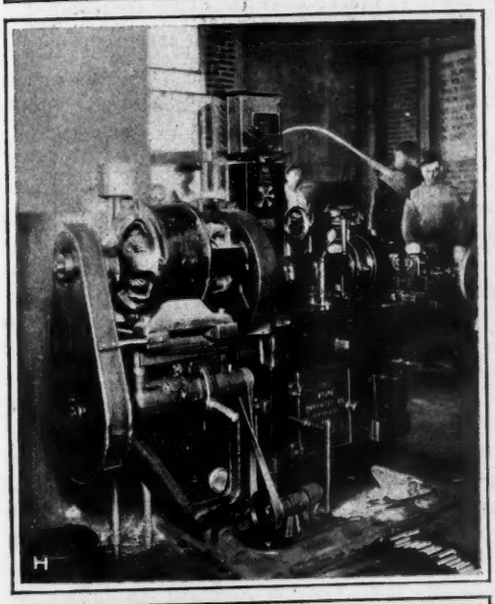
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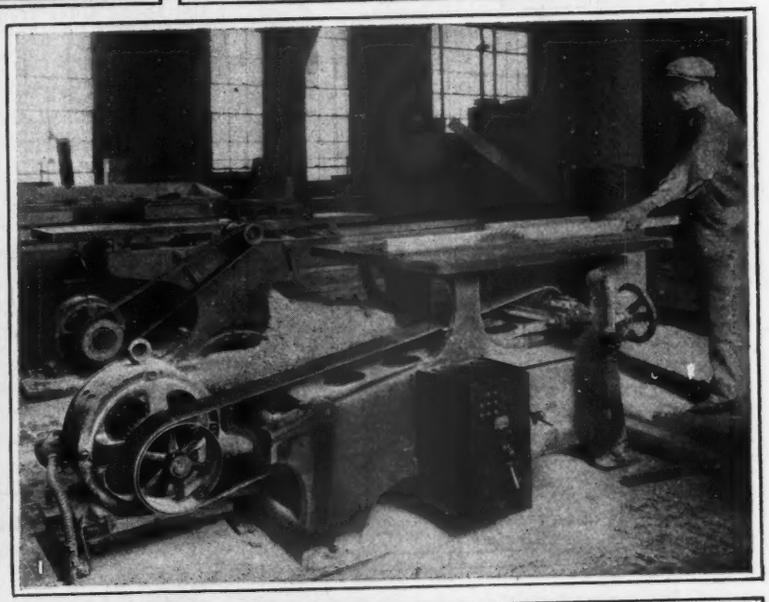
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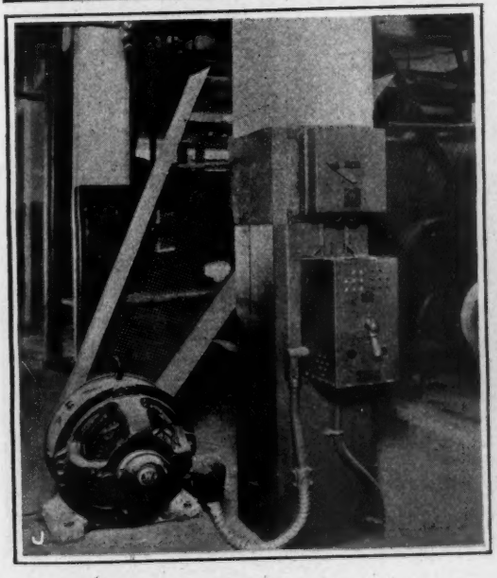
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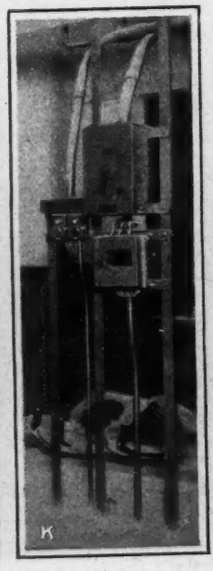
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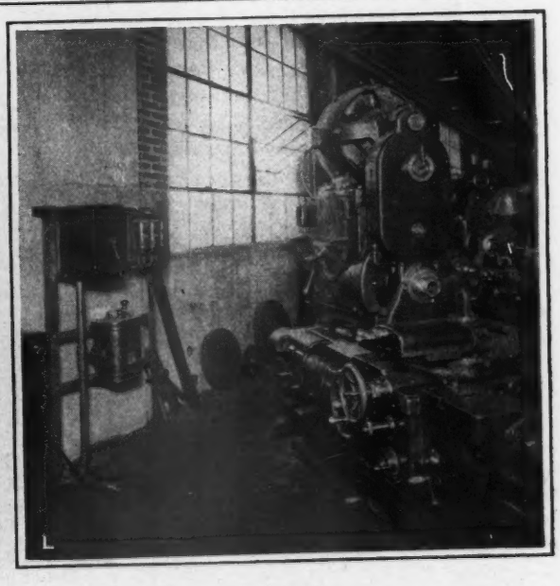
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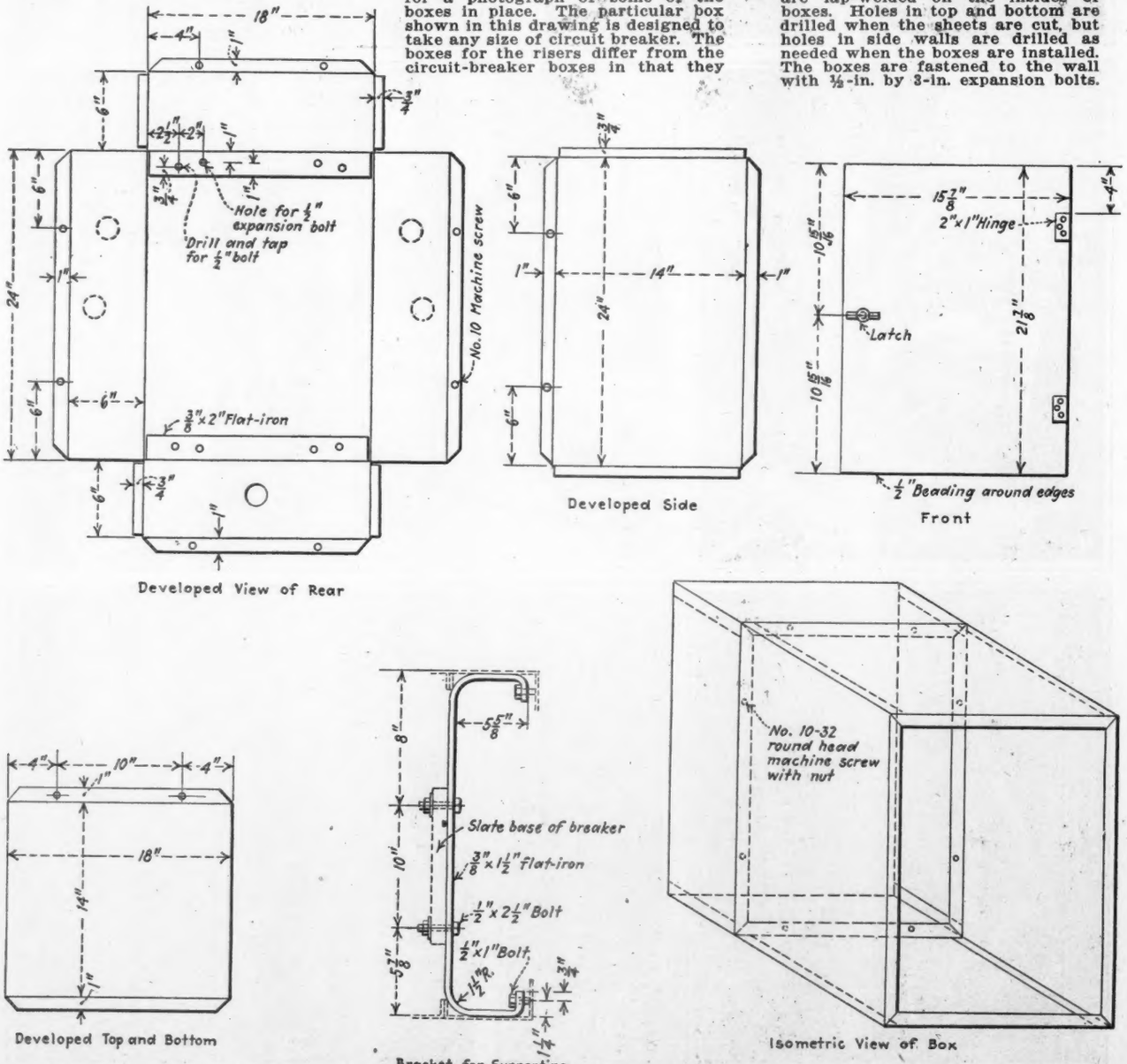
shifting the float chains. However, the inaccessibility of the floats would probably have resulted in neglect and would certainly have caused trouble if it were necessary to make the change quickly under operating conditions due to the failure of either of the units operating in the No. 1 and No. 2 positions. With this in mind, the system of transfer control switches shown in the diagram, Fig. 6, was designed and installed. The apparatus consists of three panels, each having mounted on it two eleven-pole, 30-amp. double-throw knife switches so cross-connected that, by placing the switches in the positions indicated in the chart accompanying the diagram, any pump may be connected to any float control. It is expected that the pumps will be rotated in the operating cycle at regular periods.

Portable Winches for Unloading

Another interesting feature of the installation is the method of handling the portable winches used to lift the raw-sugar bags from the deck of the ship to the dock before the raw-sugar warehouse. The hoisting equipment must be flexible enough in arrangement to allow the easy unloading of a ship from a hatch placed in almost any position along the 700-ft. dock. This was accomplished by the use of a single cargo boom placed at a height of about 15 ft. and mounted on a swivel bracket at each of the building columns as shown in Fig. 7. Anchor bolts are set into the concrete dock floor at each of the columns and four portable electric winches are provided which may be moved into position at any of the booms. The cargo whip fall is led up through a block at the outer end of the boom, down through a foot block and to the winch drum. Seven cabs, distributed along the water front, are mounted in the warehouse wall at a height which allows operators stationed in them to look over a ship's

Fig. 8—Standard type of steel box for feeder breakers and risers. All boxes are made of No. 12 gage sheet steel and are of the same height and thickness. See Fig. 10 for a photograph of some of the boxes in place. The particular box shown in this drawing is designed to take any size of circuit breaker. The boxes for the risers differ from the circuit-breaker boxes in that they are of different width and have no hinged door in front, the cover being held on with No. 10-32 round-head machine screws. The box for four risers is 20 in. wide and that for two risers is 12 in. wide. Seams are lap-welded on the insides of boxes. Holes in top and bottom are drilled when the sheets are cut, but holes in side walls are drilled as needed when the boxes are installed. The boxes are fastened to the wall with ½-in. by 3-in. expansion bolts.



deck at high tide. Each of the cabs contains a complete control equipment for one of the winches, operated by a manual drum controller. The cabs are provided with glazed sash on each of the three open sides so that the operator is completely protected in cold weather. An electric heater is installed in each cab. Four-pole plugs, distributed along the entire water front, allow the winches, when placed in position at any of the booms to be controlled from either of the two adjacent cabs. A selector panel is provided in each cab to allow the operator to connect his control equipment to whichever plug is in use, leaving dead the other plugs operated from his cab. In this way hoist service is supplied to the entire water frontage with a minimum of equipment and the greatest possible flexibility is obtained.

The Distributing System

All feeders for light, power and signal service pass to the manufacturing buildings from the power plant through underground conduits. As the yard between the buildings was to be used for both railroads and truck roads, the design of the duct system required very careful consideration. The ground was constituted almost entirely of a fill put in place during construction, outside the former bulkhead line. The yard in these areas was to be finished with a concrete pavement, and in some parts, railroad tracks were to be installed. In all places, the pavement was required to withstand the weight of heavy trucks. The final solution consists of Orangeburg fiber conduits laid in two layers under the buildings, on 6-in. centers, and

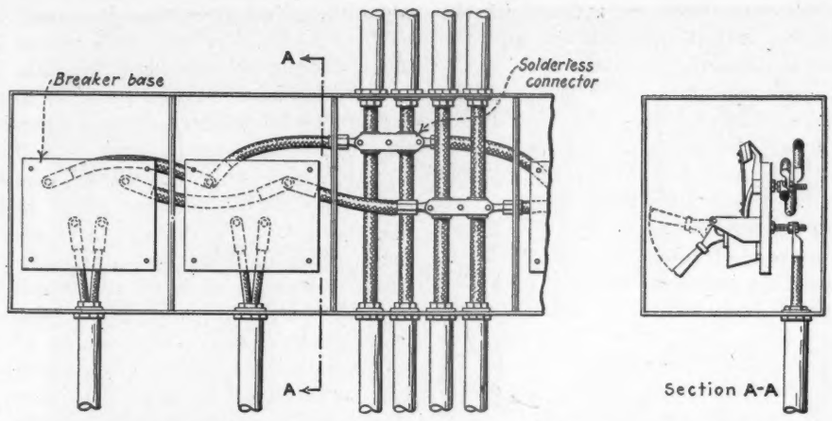


Fig. 9—Typical connections between risers and circuit breakers.

enclosed in a concrete envelope which lay directly on the 3-ft. mat which supported the buildings. The envelope was terminated near the outer edge of this mat, with enough of the fiber conduits projecting to allow a connection to be made. Between the edge of the two mats, a self-supporting bridge structure was built passing from one building to another strong enough to support the shallow earth fill, the concrete pavement, and the superposed live load of trucks and railroad equipment. This structure was built of reinforced concrete. It rests upon the edges of the building mats, allowance being made for it to slide over the top of the mats at the ends sufficiently to compensate for expansion and contraction due to temperature changes and any subsequent settling of the main structures.

All ducts for light and power are 3½-in. fiber, and at one side of each envelope a number of iron conduits (1-in., 1½-in., and 2-in.) take care of the signal, fire-alarm, clock and telephone cables. At terminal points and cable pits, the signal ducts are either carried to separate cable pits or are separated from the power and light ducts by substantial concrete walls, in accordance with the requirements of the National Electrical Code.

All underground cables except the small multi-conductor control and signal cables are paper-insulated. The smaller conductors are rubber-covered. All, of course, are leaded and pot-headed at each end. The relative merits of paper and varnished-cambric insulation for the heavy feeder cables were carefully examined, and as the A. I. E. E. (New York Section) devoted several meetings and a number of papers to the subject at the time the design was under way, full advantage was taken of the latest findings along this line. Final decision in favor of paper was based upon: (1) Ability to stand up under difficult temperature conditions; (2) lower first cost.

Feeder cables inside the buildings were run in conduit. They are varnished-cambric-insulated and covered with double flame-proof braid or tape and braid. Each feeder is carried full size straight through to the last floor that it feeds. The sizes of these inside feeders was taken according to the National Electrical Code except where these sizes were judged to be too small on account of unusual construction or temperature conditions. In such cases larger sizes were employed. For the underground feeders in ducts outside the building larger

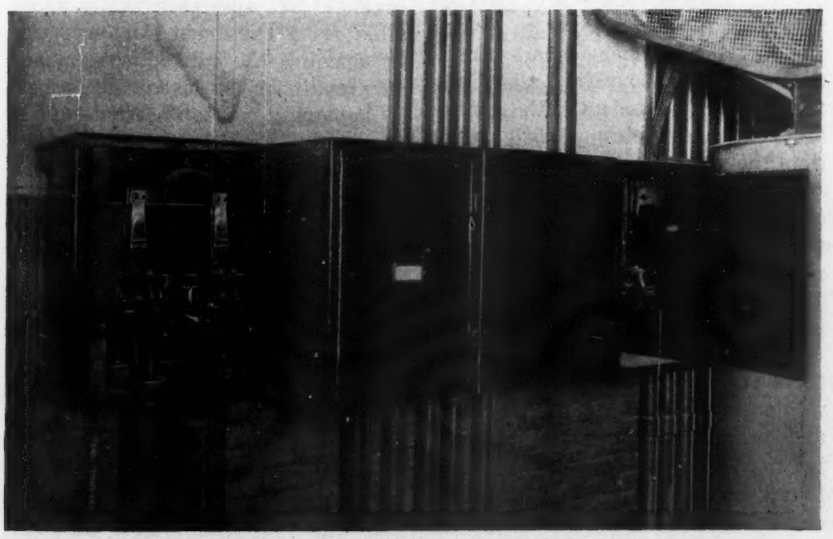


Fig. 10—Uniform steel boxes enclose risers and feeder circuit breakers. The boxes for the feeder breakers have hinged doors and the entire front may be removed to make major adjustments or to change size of circuit breakers. The front part of the box on the left has been removed. See Fig. 8 for a detailed drawing of the boxes.

sizes were used on account of the higher initial temperature and the small amount of radiation.

Temperature conditions in the duct lines at times will be difficult, to say the least, as practically the entire space between several of the buildings is filled with ducts in two layers, with a shallow earth fill above the envelope, and a 6-in. to 12-in. concrete pavement above. What the initial temperature in the ducts will be after Baltimore's July sun has beaten down upon this pavement for a few hours was difficult to determine in advance. With this in view, all underground cables have been conservatively rated, and no trouble is anticipated from this source.

From the feeder schedule shown herewith, it will be seen that in several cases two cables have been used on multiple for one feeder. This was found desirable for several reasons. Investigation developed the fact that it could not conservatively be considered safe to bend a heavy paper and lead cable to a radius of less than twelve diameters on account of the danger of opening the insulation. In a number of cases the grade at which the duct lines must be installed was fixed, by interference with water, sewer and steam lines, at a point which made very large radius bends extremely difficult. These limitations, together with the difficulty of handling heavier cable, established the size of the largest cable to be used at 1,500,000 circ. mils. However in some cases it was desired to have larger feeders than this in order to take advantage of the better diversity factor which would result from serving as many motors as possible from each feeder. These facts all pointed to the desirability of combining the carrying capacity of two cables in a single feeder. The criticism was made that a slight inequality in the length of the cables constituting one leg of a circuit, or in the resistance of connections, would result in the unequal division of load and consequent overload and heating. But the designers of the system expect no difficulty to develop from that source. Care has been taken to have the cables of equal length within the pairs, and at every point where a tap is taken off a full size equalizer connection has been installed.

The refinery as constructed is designed to take care of a future expansion of 50 per cent above the present capacity. Full provision has been made for the feeders and power plant equipment necessary for this future capacity. It was possible to proportion the feeders so that when the expansion is finally made it will be necessary only to install one additional circuit breaker panel in the space and on the supports already provided and pull in one additional feeder to each of the buildings affected. This additional feeder or breaker in each case will be of the same size as those already serving the buildings changed. A glance at the feeder schedule will indicate how this provision has been made. Duct lines have been installed throughout in sufficient number to take care of the ultimate cable requirement and to leave in addition at least 25 per cent of spares in all cases after the last cables have been installed. No spare cable will be pulled into the ducts at present, as in case of trouble, it will require only a couple of hours' work to pull and put into service a new feeder to any building.

Steel Boxes Make Cable Installation Easy

A development that added greatly to the ease and convenience of installing feeder taps and branch-circuit protective devices is the steel box shown in Figs. 8 and 10. Boxes of this kind are used as base compartments and wiring chambers on each floor. The base section is bolted to the wall at the point where the risers pass, the riser conduit entering at the bottom and leaving at the top, leaving the cables easily accessible through the open front of the box. This allows the cables to be wedged for support at each floor. Similar shallow boxes are installed alongside the riser boxes to accommodate the branch-feeder circuit breakers. The boxes are all of uniform height and depth, the circuit breaker boxes being slightly wider than the riser boxes. This gives the advantages of uniform appearance, cheaper construction in quantity, and the possibility of changing the size of circuit breaker used in a given location without changing the box.

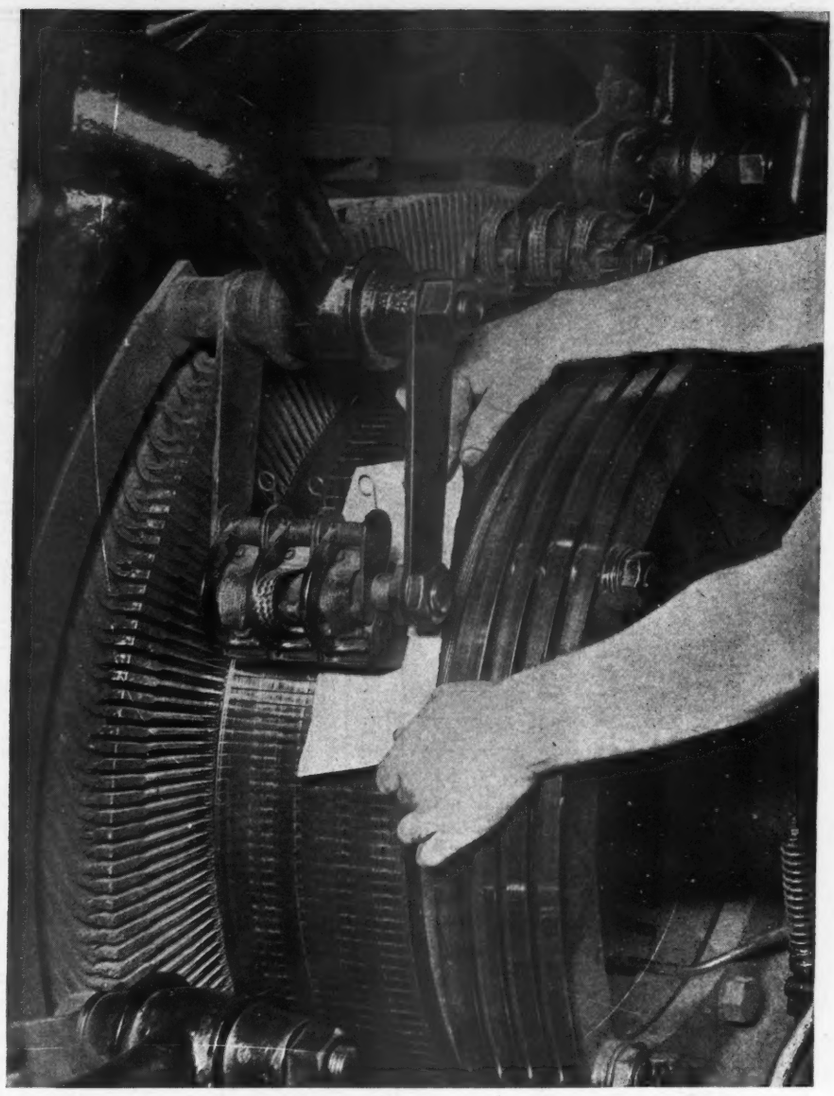
The top sections of the riser boxes serve no purpose except to bring the whole arrangement into symmetry and to give a uniform appearance to the installation. It has been found, however, that they form very convenient receptacles for the protection of instruments when extensive test readings are to be made on the branch circuits.

All boxes are drilled on the sides where they are mounted side-by-side and 2½-in. or 3-in. close nipples are installed with bushings inside the boxes to clamp them together. Clamp connectors (solderless) are used to connect the cable taps to the risers and to provide equalizer connections in the case of multiple feeders. Taps are led off to boxes in both directions wherever more than one branch-feeder circuit is required.

In the circuit-breaker boxes frames of 1½-in. by ¼-in. steel are placed to support the slate panels upon which the branch circuit breakers are mounted. All branch-feeder circuit breakers were purchased mounted on slate panels of uniform size, and the drilling of the steel panel supports is uniform throughout. The breakers are all back-connected, and connection is made to them before bolting them in place. In the cases where a large number of breakers are installed together, as occurs especially at some of the central pumping stations, the abutting sides of the box bases are entirely cut away, transite board barriers with slots are installed between breakers and all connections between risers and breakers are made with bar copper instead of cable jumpers. When the breakers have been mounted and connected, the installation has the appearance shown on the left of Fig. 10. Top sections, as shown on the right of Fig. 10, are then bolted on to all the boxes, those for the riser boxes being provided with plain screw covers, and those for the breaker boxes with hinged fronts. The breakers are now each easily accessible from the front for operation by opening the hinged covers, and for repair or extensive adjustment by removing the top sections of the boxes.

A further extension of this standard method of mounting the branch circuit breakers was made in the case of the centrifugal machine floor of the pan house. On this floor, besides some smaller incidental equipment, there are installed forty-eight centrifugal syrup extractors. Each is driven by a motor which is nominally rated at 20 hp., but in starting, is thrown on the line with only a small resistance in series, so that it takes (*Continued on page* 507)

THIS IS THE FIRST of a series of five articles which will analyze the causes and effects of evidence of brush troubles and the remedies that can be applied under a wide variety of different operating conditions. The accompanying chart covers all of the common evidences of troubles and will serve as a practical guide in studying them. Another chart will give details of the remedies.



Some Points to Observe When

Diagnosing Brush Troubles

And in Making Changes or Adjustments of Brushes or in the Repairing of Commutators

By E. H. MARTINDALE

President, Martindale Electric Co., Cleveland, Ohio

DIAGNOSING carbon brush troubles is not unlike diagnosing an illness of the human body with the added disadvantage that the machine cannot answer your questions. When a patient has the stomach-ache from eating pickles, the doctor can learn by a simple question which one of the 57 varieties his patient has eaten. But in the case of motor or generator the trouble shooter cannot even invoke the magic of the X-ray to guide him in his quest. He must recognize all the possible causes of the trouble and then by the process of elimination determine the source.

A short time ago the editor of the INDUSTRIAL ENGINEER came to the writer with the request that a short series of articles be prepared dealing with troubles encountered in the operation of carbon brushes. The writer felt rather reluctant to undertake the task mainly for the reason that he had presented the subject at some length during the past eight years in two technical magazines and before the American Institute of Electrical Engineers. Each of these articles was presented from a different view point and it did not seem possible to write another series which could be materially different from one of the others. It was the editor himself who made the suggestion that an analysis of brush troubles could be presented in chart form for everyday use in studying these troubles in machines. This appealed to the writer as a work that should have been done years ago. He believes it will be of more practical help than any previous method of treating brush troubles.

Two charts will be presented with this series of articles. The first one (page 476) shows the causes and effects of trouble at brushes or commutator. The second chart to be presented with the last article will show the remedies and the particular troubles each will help to eliminate.

MR. MARTINDALE has conducted exhaustive original studies on the performance of carbon brushes and has published the results of his findings in various publications from time to time and presented them in an elaborate paper before the American Institute of Electrical Engineers. His practical experience was secured with the Illinois Steel Company, Commonwealth Edison Company and the National Carbon Company. For a number of years he was in charge of the brush testing laboratory of the National Carbon Company.

Carbon Brush Maintenance and Trouble Chart

An Analysis of Causes and Effects of Brush and Commutator Troubles in Direct Current Motors and Generators

Compiled by E. H. Martindale,
Cleveland, Ohio.

CAUSES OF BRUSH AND COMMUTATOR TROUBLES		EFFECTS AND EVIDENCES OF TROUBLES																
		Sparking	High Mica	Flat Spots	Commutator Heating	Armature Heating	Black Commutator	Rapid Commutator Wear with Commutator Black	Rapid Commutator Wear with Commutator Bright	Pitting of Brush Faces	Glowing of Brushes	Picking Up Copper	Noisy Brushes	Loosening of Brush Shunts	Rapid Brush Wear	Burning of Brush Holder Boxes	Loss of Temper in Brush Springs
SEE FOOT NOTE	*1. Sparking*		√	√	√		√	√							√		
ARISING FROM WRONG GRADE OF BRUSH	*1. Too low carrying capacity*				√		√			√	√				√		
	2. Too little abrasive action		√		√		√										
	3. Too much abrasive action				√				√				√		√		
	4. High friction brushes				√								√				
Discussed in 1st article accompanying this chart.	*5. Too high contact drop*	√			√												
	6. Too low contact drop	√			√	√	√			√	√				√		
DUE TO FAULTY BRUSH OPERATION	*1. Brushes off electrical neutral*	√			√	√				√	√	√					
	2. Incorrect brush spacing	√			√	√				√				√			
	3. Brushes too thick	√			√	√				√	√	√					
Will be discussed in 2nd article.	*4. Brush pressure too low*	√	√		√		√	√		√	√				√		
	5. Brush pressure too high				√				√				√		√		
	6. Unequal brush pressure	√								√	√			√			
	7. Brushes tight in holders	√	√	√			√	√		√	√				√		
	8. Worn brush holders on machines running in only one direction													√		√	
	9. Worn brush holders on reversing motors	√								√	√		√	√	√	√	√
	10. Brushes operated at wrong angle												√				
	11. Brushes chattering	√															

	10. *Brushes operated at wrong angle*													√				
	11. *Brushes chattering*	√	√		√									√	√	√		
	12. *Too high ratio of brushes to commutator surface*				√													
	13. *Lubricated brushes*						√											
	14. *Loose brush shunts*																√	√
	15. *Loose terminal screws*																√	√
ARISING FROM COMMUTATOR DEFECTS	1. *Brush studs not parallel to commutator bars*	√			√	√				√	√				√			
	2. *High mica*	√		√	√		√	√						√		√		
	3. *High bar*	√		√										√		√		
	4. *Low bar*	√		√														
	5. *Eccentric commutator at high speed*	√		√														
	6. *Rough commutator*				√											√		
	7. *Use of lubricant on commutator*				√		√					√						
	8. *Dirty commutator*				√													
	9. *Difference in hardness of bars*			√														
	10. *Difference in hardness of mica*			√														
	11. *Commutator not properly finished after turning*				√											√		
	12. *Commutator too small*				√													
CAUSED BY ARMATURE AND FIELD DEFECTS	1. *Loose end connection*	√		√														
	2. *Open circuit in armature coil*	√		√														
	3. *Unbalanced armature winding*	√		√	√	√												
	4. *Mechanically unbalanced armature*	√		√														
	5. *Jammed armature laminations*					√												
	6. *Partial short in shunt field*	√																
	7. *Series field poorly adjusted*	√	√		√	√												
	8. *Series field bucking*	√	√		√	√												
	9. *Poor adjustment of interpoles*	√	√		√	√												
	10. *Unequal air gaps*	√			√	√												
	11. *Worn bearings*	√			√	√												
	12. *Flux distribution*	√			√	√												
FROM EXTERNAL SOURCES	1. *Overloads*	√			√	√									√			
	2. *Surges of load on line*			√														
	3. *Cross currents between generators*	√		√	√	√				√					√			
	4. *Poor belt lacing*			√														
	5. *Pound of engine*			√														
	6. *Unstable foundation*	√		√														

Will be discussed in 3rd article.

Will be discussed in 4th article.

Will be discussed in 5th article.

NOTE: Sparking is the effect of some other trouble, but at the same time it is the immediate cause of so many other troubles that it has been shown among the causes of commutator troubles.

A very small percentage of brush troubles is primarily due to the wrong grade of brush. It is true that in any case of trouble a change of brush may prove a great help, but it is like giving morphine to a suffering patient. It has quieted the effect, but does not remove the cause of the trouble.

The carbon brush manufacturers have been too anxious in the past to try to develop a new brush to cure every trouble instead of telling the operator frankly that the machine is at fault. I do not blame the brush manufacturer; he can hardly do otherwise. If he should tell the average operator that the trouble is in the machine, but could not tell him which one of the 46 causes was responsible for his trouble, the operator would think the manufacturer was only trying to shift the blame from the brushes. He would probably call in another manufacturer, get a set of brushes from him, and then he would be sure the first manufacturer was shifting the blame because the second man gave the machine the right dose of morphine.

Four Grades of Brushes Are Sufficient in Most Cases

Four grades of brushes, excluding metal or metal composition brushes, should be sufficient for any plant if the equipment is kept in good condition. If brush manufacturers would adopt a brush letter code, somewhat like the following, for their trouble grades, it might have a salutary effect.

I. B. S.—For incorrect brush spacing.
B. O. E. N.—For brushes off electrical neutral.
U. B. P.—For unequal brush pressure.
H. B.—For high bars.
D. A. M. N.—Designed for any machine neglected.

I have seen many a maintenance man who had been getting poor service from brushes, without complaint to the brush manufacturer, call in a competitor, follow his recommendation of grinding the commutator, undercutting the mica, adjusting his brush spacing and brush tension, put on the new brushes and never give the old manufacturer another chance at analyzing the trouble when all the benefit was from the change in his operating conditions.

It is important that the meaning of several brush terms frequently used, should be thoroughly understood when selecting brushes. Brush resistance is practically negligible as it averages only about 1/10 of the contact resistance. Carrying capacity is determined by the combination of contact drop and friction. There are, therefore, only three inherent characteristics of brushes which materially affect their operation, namely: (1) Abrasiveness; (2) coefficient of friction and (3) contact drop. The first two are mechanical, the last electrical.

Abrasive action should not be confused with hardness. The abrasiveness of a brush depends on its impurities which usually consist of mica, quartz, silica or iron oxide. A very hard brush free from impurities will not wear a commutator while a very soft graphite brush with a small percentage of impurities will produce rapid commutator wear.

An abrasive brush will always have a high coefficient of friction, but brushes may also have a high coefficient of friction without being abrasive.

It will be noted from the chart that too much abrasiveness is indicated by commutator wear with a bright raw copper surface, noisy brushes, rapid brush wear and commutator heating. The first effect is sure to be present, while the others may be present in a smaller or greater degree depending on the construction of the machine and the wearing qualities of the brush.

Too little abrasive action will be evidenced by high mica, a black commutator and commutator heating. Undercutting the mica may stop all of the trouble and is better than using abrasive brushes which will wear the commutator.

Commutator heating may be produced by brushes with either too great or too little abrasive action. In the former case the heating is due to friction while in the latter case it is due to burning caused from poor contact between the brushes and commutator.

Large Amount of Power Consumed by High Friction Brushes

High friction brushes are usually noisy and produce commutator heating. Unless one has figured the amount of power consumed by high friction brushes he may be surprised at the loss caused by this characteristic. In an article published several years ago, the writer showed where on a 100-kw., 220-volt generator, the annual loss from high friction brushes amounted to $277.20 as compared to $37.08 with low friction brushes. These figures were based on an 8-hour day, 300 days per year, with a power cost of 1½ cents per kilowatt hour. There is little excuse for high friction brushes unless abrasive action is necessary. It is better to have a brush with too little abrasive action and stone the commutator occasionally than to have a brush with too much abrasive action. The saving in friction loss will pay for the stones used many times over. The total commutator wear will be less and the reduced heating will permit a higher load on the machines.

Effects of Too High and Too Low Contact Drop

Too high contact drop in brushes will produce under-commutation with some commutator heating and a small amount of sparking, but these effects are seldom sufficient to cause serious trouble except on low voltage equipment, such as plating generators.

Too low contact drop has more serious effects as it permits over-commutation causing heavy short circuit currents in the coils undergoing commutation, or in other words, in each armature coil as the commutator bar connected to it passes under a brush. This causes both commutator and armature heating, severe sparking with all its attendant evils and in severe cases glowing and pitting of the faces of the brush.

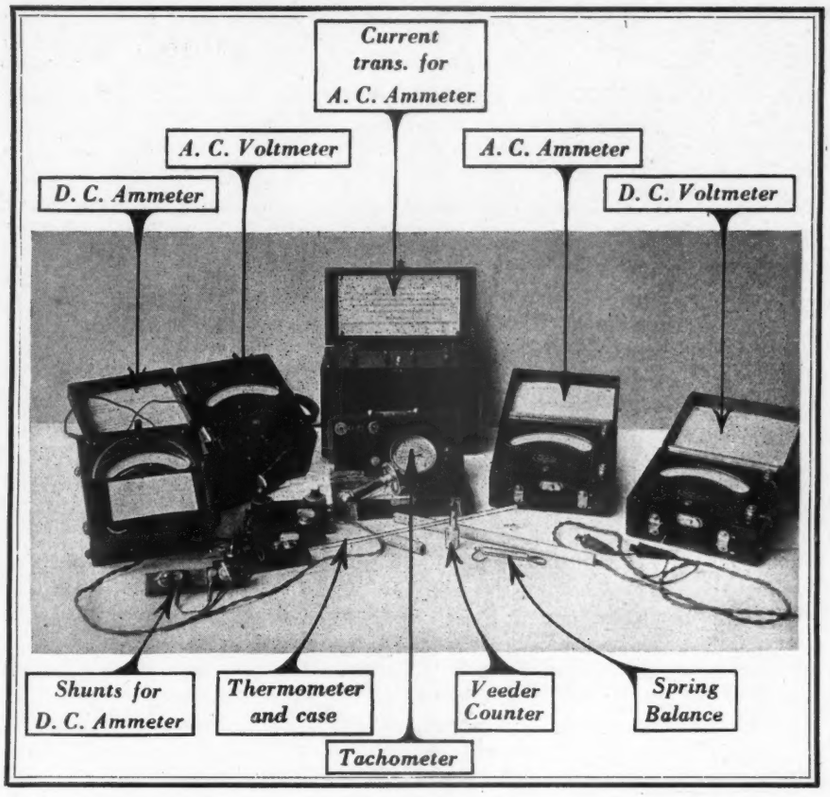
The grade of brush installed on a new machine may be the best when the machine is new, but as bearings, brush holders and commutator become worn causing respectively variation in air gaps, setting and spacing of brushes, and an increase in the number of bars spanned by a brush, it may be necessary to change to one with higher contact drop. Usually the motor and generator manufacturer takes all these conditions into account when selecting the brushes for a machine.

All of the brush manufacturers maintain a highly skilled staff of engineers who are glad to assist in the selection of the proper brushes for equipment. Their services are free and their experience should be drawn upon by any industrial plant man who carries the responsibility of selection of brushes and their satisfactory operation.

Here Are Some Pointers on

Instruments Needed in Maintenance Work

And How They Can Be Used to the Best Advantage in General Testing



By J. M. WALSH

Electrical Engineer, Gurney Elevator Company, Honesdale, Pa.

THE FUNCTION of the shop electrician should be the maintenance of the electrical system of his factory and all that pertains to that system in the most up-to-date and efficient condition possible with his equipment and training. He should realize the dependence of the entire plant upon its electrical system, and the possibilities for increased production and efficiency that lie in the improvement of that system. It should be regarded not as something separate and apart from the rest of the concern, but as really one of the main arteries which is responsible in no small degree for the well-being of the entire establishment.

In taking hold of his job, the shop electrician ought to look first to the equipment of his department; that is, to the means provided for properly performing his duties. In the first place, there should be a set of electrical measuring instruments, and this can hardly be too complete in frequently used types and sizes.

A voltmeter of range suitable for the voltages encountered in the shop, and an ammeter, preferably of the external shunt type with a good assortment of shunts, constitute the basis of the set. Both of these instruments should be of a rugged, portable type of the self-contained sort; that is, without a separate carrying case, but so built as to be entirely covered and protected when closed. A wattmeter is valuable but not really essential unless alternating current is used on the power or lighting circuits. In this case the wattmeter will take the place of a power-factor meter with greater advantage and at lesser cost. And, by all means, a direct-reading photometer of modern construction should be included in the equipment. The value to the shop electrician of this comparatively recent adaptation of a laboratory instrument can hardly be overestimated. If it is not possible to purchase one outright, although the price is very reasonable, arrangements may easily be made to rent one from the manufacturers long enough to make a lighting survey of the plant.

A testing thermometer graduated in degrees Centigrade is quite inexpensive and often serves a valuable purpose in determining whether or not a particular piece of apparatus is operating at too high a temperature. The upper limit of the scale should be 150 deg. above, and the lower limit about 40 deg. below the zero point. There ought also to be included a small, spring balance to be used in getting accurate information on the actual brush pressures in use on the shop motors. The kind known as Sportsmen's Balance answers very well for this purpose; it is graduated in ounces and pounds up to six pounds. Finally, a tachometer or speedometer is necessary. There are many types of this instrument, but one of the handiest is that known as the "aeroplane," which holds its maximum speed indication after being removed from the machine. If an instrument of this type is deemed too expensive, an excellent substitute is a Veeder counter used in conjunction with a stop watch or even with an ordinary pocket watch.

Items of importance which claim the attention of the shop electrician and his assistants may be grouped under the headings of surveys which they should make. These surveys or investigations pertain to the lighting system, the motors, and the power and distribution lines of an average size of industrial works.

Under the lighting survey one of the first matters to be checked is the voltage at the lamp sockets. The voltmeter must be connected directly to the socket, and not merely to the panel board terminals of the circuits. This will disclose any discrepancy between the rated voltage of the lamps in use and the voltage of the circuit on which they are being

MOTOR SYMBOL NO. AHP 12 E. LOCATION BLACKSMITH SHOP. DRIVING OIL PUMP.

MFR. ELECTRO DYNAMIC CO.. MFG'S NO. 15-16238.

TYPE PLAIN SHUNT, INTERPOLE; R.O.B. NO. OF POLES 4. CONTROLLER 1 ARMATURE STEP. GURLEY ENCLOSED STARTER;

	HP	VOLTS	AMPS.	R. P. M.	PERIOD	SP. OPERATING CONDITION;
RATED	3	220	10.5	875	2 HRS.	LOCATED NEAR HEAT TREATING FURNACES — ATMOSPHERE VERY WARM.
ACTUAL	2.5	230	8.1	980		

BRUSHES-NO 4. SIZE 3/8"×4" TYPE NATIONAL #255. FUSES-SIZE 30A. TYPE UNION RENEW.

PULLEY DIAM. 4" FACE 5" (WOOD) SHAFT DIAM. 1 1/8" LENGTH 24 1/4" KEY 4"x 3/8"

SPECIAL DATA;

PARTS IN STOCK	DATE	NATURE OF REPAIRS.
1 REAR BRG. 1 FRONT BRG. 2 SETS OF BRUSHES.	3/8/18	FRONT BEARING REPLACED

Here is a motor-record card that is well worth copying.

burned. The importance of this matter and the value of having the lamp voltage the same as that of the circuit can be easily demonstrated by referring to the table of lamp voltage changes that is given in Croft's American Electrician's Handbook, page 665.

Photometer tests should be made to determine the intensity of illumination in all parts of the plant. Readings should be taken on all working surfaces, around the various machines, on the assembly floor, in the drafting room, and in the business offices. The State Code requirements for intensity of illumination should be ascertained, where a code is in force, and the necessary changes made in the lighting system to conform to it. In most cases the code requirements are the minimum, and it will be found advantageous to use slightly higher intensities than those called for therein.

Distribution and location of the sources of light should be checked during the lighting survey. Attention should be paid to these matters, with especial reference to the State Code, as in many instances the lighting systems have been installed prior to the publication of the codes. Particular notice should be given to lighting conditions in the foundry, if there is one attached to the plant. The general condition of the lamps and their shades, as well as their manner of installation, should be carefully noted. A thorough and practical system of lamp cleaning and replacement should be installed. The value of regular and efficient lamp and shade cleaning will be realized in the results obtained in better lighting and longer life of lamps.

A schedule should be mapped out to insure the cleaning of every lamp and shade in the plant at regular intervals suited to the local operating conditions and this schedule should then be closely followed.

The motor survey should cover the careful examination of every motor in the shop, with a view to determining its fitness for the work it is doing. Power readings should be taken under various conditions of load and the behavior of the motor carefully noted. This survey is often of the greatest value in disclosing costly leaks through inefficient motoring. This statement applies in particular to establishments which were expanded rapidly during war times, when definite motor requirements could not always be either estimated or met. Finally, all data pertaining to each individual motor should be accurately entered on a suitable card form and properly filed.

The motor survey embraces also an investigation of the methods employed in starting the various motors. This is a matter that will, in quite a few factories, disclose a big field for improvement. Proper starting devices must be made the rule on all motors and should preferably be of the totally enclosed type. In the case of direct current applications the armature starting resistance should be automatically cut in in order to prevent blowing of fuses when starting. The use of circuit breakers in connection with all motors other than those of fractional horsepower is desirable practice, and is now quite reasonable in cost, since the introduction of the Cutter Company's U-Re-Lite breaker of small size that is enclosed in a steel box.

The line survey covers an investigation of the different power and lighting mains and services throughout the plant. This is to ascertain whether or not the existing lines are ample for the loads they carry. Cost of power wasted is an item that may be surprising when calculated for a heavily loaded circuit. Of course, the factors of copper cost and power cost must be properly considered in this matter. In any event, however, where the load is appreciable on any particular line the economy of replacing the present conductor with a larger one should be carefully looked into, especially if an extension is planned. This is very advisable now, when copper is at its low mark. Fusing of the various branch circuits is often carelessly done, and it will pay to examine all fuse blocks and see that they are now of proper size or are replaced by ones that have an adequate rating.

Taking brush-pressure readings with a small, spring balance.

A piece of fine copper wire is formed into a loop and the lower end caught under the pressure finger of the brush holder. The hook of the balance is engaged in the upper end of the loop. The balance is then slowly raised so that the pull is straight up from the brush. The operator feels with his finger when the pressure is taken up by the balance and notes the reading of the latter.

Step-by-Step Details By A. C. Roe on

Winding Small Motors

With Some Different Type Coils Suitable When Stator Slots Are Partially Closed

IN MODERN motors having partially closed slots, four different kinds of windings are commonly used: (1) The basket winding; (2) two-layer diamond coils, one coil side per slot; (3) two-layer flat diamond mush coils, and (4) two-layer diamond mush pulled coils. Another type sometimes found is that having strap-copper conductors. These windings will be discussed in the order in which they are named.

A good idea of the way to put in a basket winding is shown in Fig. 1. This winding derives its name from its appearance. As can be seen, the coil ends interlace in somewhat the same fashion as the parts of a woven basket.

In the first place, a basket winding can be used only where the number of slots is even. And in the second place, the number of slots spanned by a coil must be odd. In other words, the coil pitch must be 1 and 4, 1 and 6, 1 and 8, 1 and 10, etc. (the last figure being always even).

To check the pitch of a basket winding to see whether or not the coils may be put in with this pitch, the following scheme may be used. Put down a line of figures like the middle line shown below to represent the numbers of the slots in the motor. Below these put the numbers of the bottom sides of the coils. The coil numbers should be directly under the numbers of the slots in which the coils lie. As shown, coil No. 1 is below slot No. 1, coil No. 2 is below slot No. 3 (skipping one slot because it is a basket winding), coil No. 3 is below slot No. 5, etc. After putting down the numbers representing the bottom of the coils, place in a line above the slot numbers the numbers corresponding to the top side of the coils. Thus, in the example where the pitch is 1 and 6, the top of coil No. 1 is in slot No. 6, coil No. 2 is in slot No. 8, etc.

Example for pitch 1 and 6:

Top of coil No..						1		2		3			
Slot No.....	1	2	3	4	5	6	7	8	9	10	11	etc.
Bot., coil No....	1		2		3		4		5		6	

By completing the lines of figures it will be seen that with a pitch of 1 and 6 each bottom and each top coil will have its separate slot. Taking a pitch of 1 and 7, however, we find it is impossible to wind the motor.

Example for pitch 1 and 7:

Top of coil No..						1*		2*		3*			
Slot No.....	1	2	3	4	5	6	7	8	9	10	11	etc.
Bot., coil No....	1		2		3		4		5		6	

*One coil side is already in these slots, and therefore the winding is impossible with this pitch.

The top of coil No. 1 will fall in slot No. 7, which is already occupied by the bottom of coil No. 4. Likewise, the tops of the succeeding coils will fall into slots already occupied.

Drawing *C* in Fig. 2 shows the shape of a basket-winding coil. The coil is wound mush on a shuttle. The

IN THIS ARTICLE A. C. Roe gives the details of shop methods for winding small two-phase and three-phase stators. These include directions for checking the coil pitch, insulating the core and slots, taping the coil ends, etc. The types of winding covered are the basket winding; two-layer windings with one diamond coil side per slot; the flat diamond mush coil; two-layer diamond mush pulled coils, and the winding with strap-copper conductors. This is another contribution of practical information from Mr. Roe's long experience in repair work. He is the shop superintendent of the Detroit Service Department of the Westinghouse Electric & Manufacturing Company.

cell side, *F*, is at the bottom half of the coil and is made longer than *E*, the top, as the bottom has to be bent down. The leads are brought out on the long or bottom side. This makes the coil connections come on the outside.

Insulating the Slots and Core

In *B* of Fig. 2 is shown how the core should be insulated with fiber rings to protect the coils from the iron when they are shaped down. The insulation used consists of 0.023-in. fishpaper or combination paper. This combination paper has a fishpaper base with treated cloth shellacked to it, making a good mechanical and electrical slot insulation. The cell should be cut about ⅜ in. to ½ in. longer than the slot and should be bent to conform to the shape of the slot, as shown in the close-up view, *B* of Fig. 1.

Fig. 1 shows a 48-slot, 24-coil, six-pole motor, with a pitch of 1 and 6. Note in *A* of Fig. 1 that there are only two throw coils up. The way in which the throw coils are kept up is illustrated in *A* of Fig. 2, which represents the same winding as that in Fig. 1. As will be noticed, there is only one coil side per slot. Drawing *a* in *A* of Fig. 2 shows the first coil with only the bottom half put in slot No. 1. The top half is left up. The bottom half of the coil is then bent down as shown in *B* of Fig. 1 and *B* of Fig. 2. It is bent down in this way so that the slot adjacent to the right is left clear for the top half of another coil to cross and enter the slot. Then the wedge is put in. After the coil has been shaped it is taped with one layer of 0.008-in. treated-cloth tape and one layer of 0.007-in. cotton tape, both layers being half-lapped. In putting on the tape the slot cell and wedge are sealed with the tape as shown in *B* of Fig. 1. In other words, the tape is wrapped around the ends of the cell and wedge which stick out of the slot. The throw coils, when they are made, are taped only to the line X-X in *A* of Fig. 2. These ends are taped later, after they are put in place in the slots. All other coils are taped complete as they are first placed in the slots.

After the first coil is in place, coil No. 2 is put in the second slot to the left, as shown in *A* of Fig. 2. An empty slot is left between coils No. 1 and No. 2. Another slot is skipped and coil No. 3 is placed as shown. The top half of this coil can be put into a slot. This is allowable because the top of No. 3 will fall in a slot next to the bottom of coil No. 1. Until this condition is reached, only the bottom half of a coil can be put into a slot. Continuing in this manner, it will be seen that the top of coil No. 4 falls in the slot between the bottom of coils No. 1 and 2. This is correct and the winding should be completed in this way.

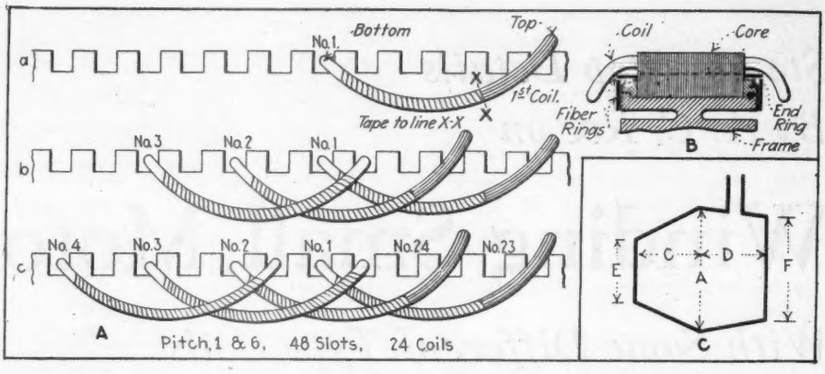


Fig. 2—How the coils are inserted in winding a basket winding.

The drawings at *A* show three steps in the winding. At *B* is a side view of a coil showing how the ends are bent down. Notice also the fiber insulating rings which are used on some makes of motors to keep the coils off the iron. At *C* is the shape of the coils used in this winding. *F* being the bottom coil side and *E* the top coil side.

Fig. 1—The coils lie like this in a basket winding.

There is only one coil side per slot. The bottom sides of the coils are put in every other slot leaving the empty slots to accommodate the top sides of coils.

Two-Layer Winding With One Coil Side per Slot

An example of the two-layer winding having only one coil side per slot is shown in Fig. 5. This is a picture of the wound stator of a 72-slot, 36-coil, six-pole, three-phase stator having a two-layer, diamond-shape, one-coil-per-slot winding.

This type of winding differs from a basket winding in that the coil is usually a pulled coil (mush) and diamond shaped, and that, in winding, as many slots are skipped as there are coils per group. In the basket winding, it will be remembered, only one slot is skipped before putting in each succeeding coil. Fig. 4 illustrates the principle of the two-layer, one-coil-per-slot winding. The top drawing shows how the coils are inserted if there are two coils per

group. The bottom half of the first two coils are put in slots 1 and 2, then two slots are skipped and two more coils are put in, etc. This is the grouping used in the winding in Fig. 5. The bottom drawing in Fig. 4 shows a winding in which there are three coils per group. The general rule is: Put in adjacent slots as many coils as there are in one group; then skip the same number of slots and repeat.

The possibility of using a certain pitch may be checked in the same way as explained for a basket winding. For instance, with the stator in Fig. 5 there are 72 slots and 36 coils. This is a three-phase, six-pole machine and therefore there will be (3×6) equals 18 groups. As there are 36 coils, there will be two coils per group.

If the pitch is 1 and 11, the check is as follows:

Top of coil No..										1	2			3	4	
Slot No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Bot., coil No.....	1	2			3	4			5	6			7	8		

The tops of the coils fall in slots not occupied by the bottoms of coils, and therefore this pitch is practicable. However, a pitch of 1 and 12 would not be possible, as shown in the following:

Top of coil No..											1	2*			3	
Slot No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Bot., coil No.....	1	2			3	4			5	6			7	8		

*Falls in a slot already occupied.

Before putting on this kind of a winding the slots are insulated as for a basket winding. Also, as each coil is put in place it is taped in the manner described for a basket winding.

Two-Layer Windings With Flat Diamond Mush Coils

Windings using a flat diamond mush coil are the commonest in small stators. There are a number of different ways of insulating and inserting such coils. Fig. 3 (*A*, *B* and *C*) shows how the slots are insulated. A slot cell of combination insulation is used. This has a fishpaper base with tan treated cloth shellacked to it. The best thickness is a total of 0.023 in. This cell is folded to fit the slot as shown, then a treated-cloth slider (cell) is used to protect the wires as they are fed into the slot. After the bottom half of the coil is in place, the slider is pulled up to the top of the slot and cut off as shown in *A* of Fig. 3. The coil is then forced down to the bottom of the slot and the ends of the slider are turned over on the coil. A spacer or "willie" is then put on top of the coil as shown in *B*. This spacer can be flat or channel-shaped. For springy coils and tight jobs, the flat spacer wide enough to make a tight fit is the best. When it is hammered down, the edges bind on the sides of the slot and hold the wires securely. The spacer, however, must not be made tight enough to tear the slot insulation.

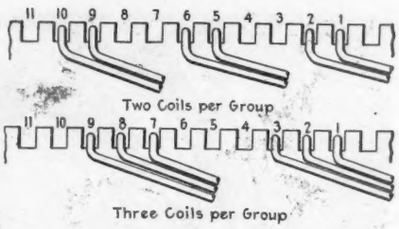


Fig. 4—Starting a two-layer winding with one coil side per slot.
The winding shown in the upper drawing has two coils per group. It is like that shown in Fig. 5. In putting in the coils two slots are filled and then two slots are skipped. In the lower drawing where the winding has three coils per group, three slots are filled and three slots are skipped. The empty slots will be filled later by the top sides of coils.

Fig. 5—Two-layer winding with one coil side per slot.
This winding has two coils per group. It is put in the slots as shown in the upper drawing, Fig. 4.

Another slider is put in for the top coil. When the coil is in place this slider is cut off and bent over the coil and a wedge inserted. The wedge can be flat or curved. For narrow slots the curved wedge is the better, as the flat wedge has a tendency to slip up. The curved wedge is made from 0.056-in. fishpaper.

In Fig. 6 are shown three steps in winding with diamond mush coils. In "*A*" may be seen the condition in which the coil comes to the winder. The coil is taped in the coil department, starting 1 in. on the bottom slot section and ending up on the end 1½ in. outside of the top cell. The leads are brought out on the bottom of the coil 1 in. from the diamond point or nose. They are reinforced with three turns of tape, thus sealing up this point and keeping out dust and dirt.

In putting this coil into the slot, the winder spreads the bottom untaped section of the coil out flat with his fingers, then starts the coil into the slot, putting the center of the bottom slot section into the corner of the slot as shown. Then the coil is pushed across the core until the part in the slot reaches the other end of core, when the coil drops down. It is now entirely down in the slot, but it sticks out too far at one end. It is brought back to its proper position by a sort of see-saw motion. After one gets the knack, he can put in a coil very quickly.

The top half has to be threaded in

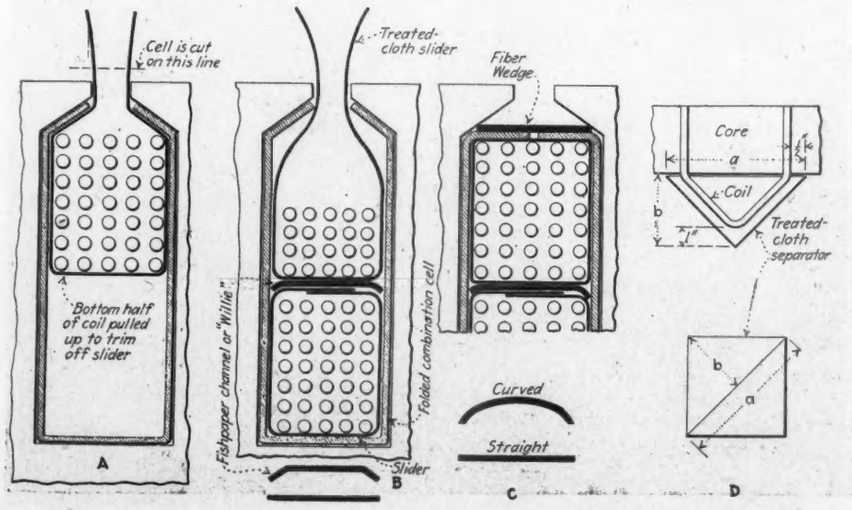


Fig. 3—Slot insulation and end insulation for coils.
A, *B* and *C* illustrate the slot-insulating cell, the treated-cloth sliders, the fish paper spacer "willie" and the fiber wedge. At *D* is shown how to cut the treated-cloth triangles which are placed between the ends of coils in the stator.

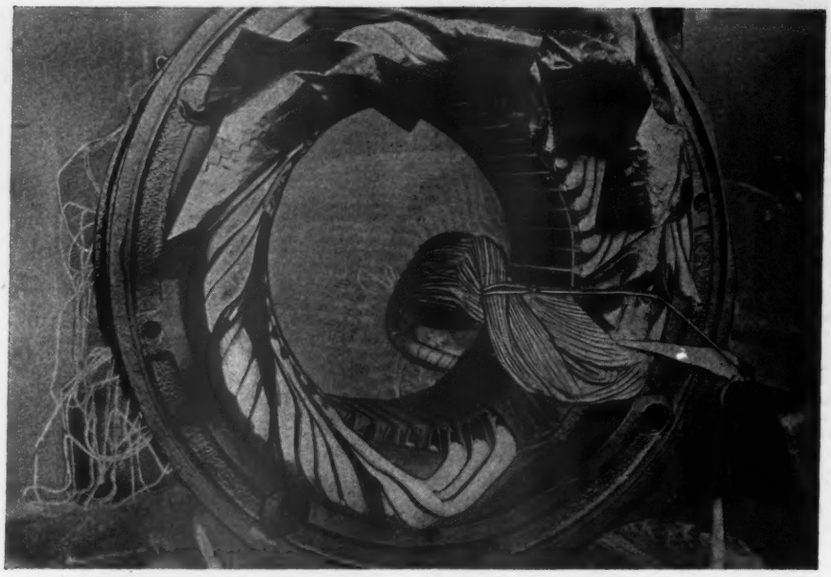


Fig. 7—Throw coils tied back to allow bottom side of last coils to be inserted.
This is a two-layer winding with diamond mush pulled coils.

a few wires at a time. For this reason, when the coil is being made the tape is not brought around the top cell bend. However, this bare portion must be insulated. This is accomplished by placing one end of a length of 1-in. cotton tape ⅞ in. inside the slot under the treated-cloth slider for the top side of the coil. This slider projects well out of the slot. After the coil is in place this slider and the tape form a lapped joint on the coil. This is well illustrated in *C* of Fig. 8. The quickest way to get the wires of the top coil side into the slot is to use a 1/16-in. fiber drift as shown in *B* of Fig. 6. Start with the wire nearest the core. Push one end of this wire into the slot with the drift. Pressing down with the drift, slide it along the wire until it is forced into the slot. The principle to learn is to get the wire nearest the slot free from crossings with other wires. After it is once mastered, this method is a time saver. The tape is then wound around the coil and slider, forming a sealed junction. It is see-sawed up and down until the short end projects about 1½ in. above the iron. This end is then tucked down into the slot by means of a blunt and dull knife as shown in *C* of Fig. 6. Then the long end is wound around the bare part of the coil until it is covered. The weakest spot in the winding is at the end of a coil. Dust, etc., will accumulate at this point, and if the coils are not well taped a failure will result.

Extra insulation is required at the point between two coils of different phases. One good way to furnish such insulation is to insert triangles of tan treated cloth between the phase coils. Such pieces are shown in *A* of Fig. 6 and *C* of Fig. 8. These pieces of cloth are cut as shown in *D* of Fig. 3. The distance *a* equals the distance between outside edges of the coil plus 1 in. The length *b* equals the distance from the iron to the nose of the coil plus 1 in. A trial piece should be cut to the proper size. Then, using this as a guide, cut the cloth into squares as shown and cut these into two pieces along the diagonal. Insert one of these triangles at each end of the coil before putting the top side in the slot. The edges of the triangle are allowed to project until the winding is completed. Then they are trimmed close

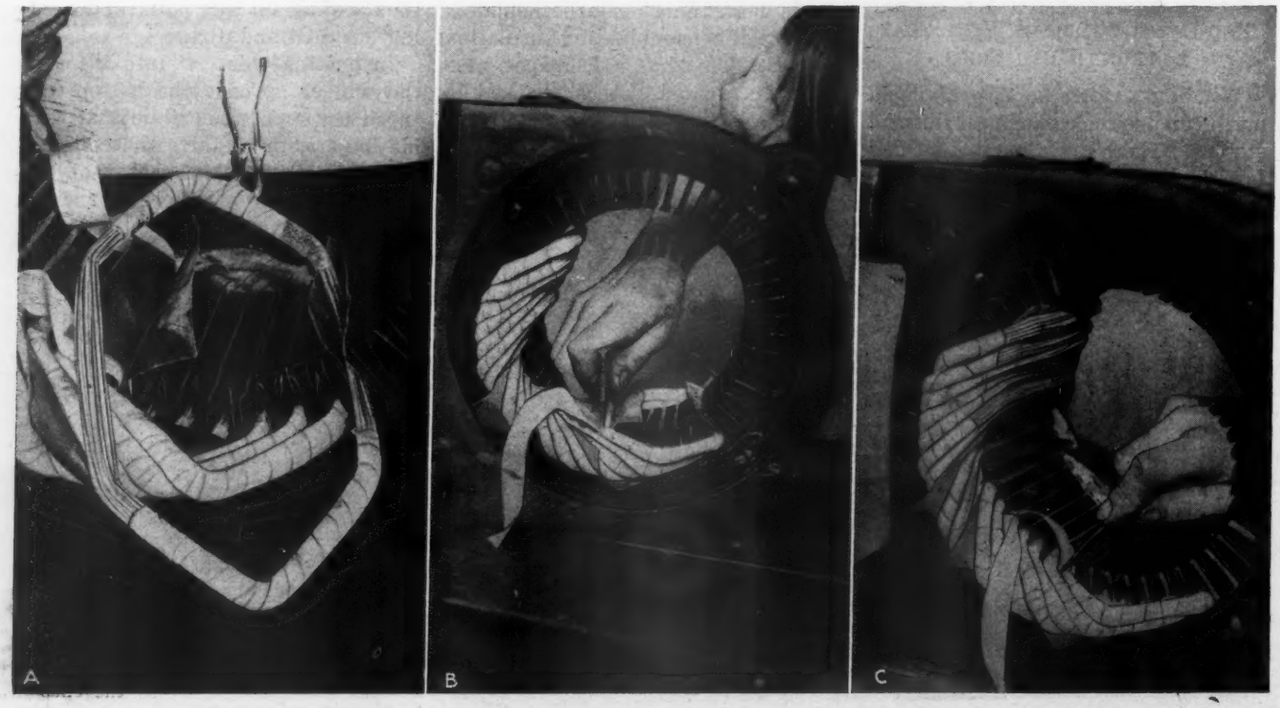


Fig. 6—Putting in flat diamond mush-wound coils.
The bottom side is started in the slot as shown at *A*. The top side of the coil is forced in, one wire at a time by the help of the fiber drift shown in *B*. The part of the top side next to the slot is insulated with cotton tape, which is inserted under the slider before the coil is started in. The picture at *C* shows how the short end of this tape is tucked down in the slot after it is passed over the coil.

to the coils. When properly done, this makes a thorough job for motors which must operate in dirty, dusty or damp places or in locations with metallic particles in the air.

There are other methods of insulating the coil ends. One of these is used with coils which are not taped. The end insulation is then furnished entirely by the treated-cloth triangles inserted beneath each coil. This type of insulation is shown in *A* of Fig. 8. This method of insulating the coils is very quick and is satisfactory for most applications when the complete winding is thoroughly impregnated. For 110, 220 and 440 volts, one thickness of 0.009-in. insulation is sufficient. It is not necessary to put an additional thickness between phases.

Another method of insulating coil ends where extra phase insulation is required, due to dust, etc., is shown in *B* of Fig. 8. This consists in taping only the last coil of each group with one half-lapped layer of 0.007-in. cotton tape in addition to the treated cloth between coil ends.

Two-Layer Winding With Diamond Mush Pulled Coils

The mush pulled coil is another type that is used on partly closed slots of stators. Such a coil is wound in layers but is not taped. It is tied together at each of the diamond points. These coils are fed into the slots in the same way as the flat diamond mush coils just described. The picture at the head of this article shows these coils. At the left is a complete stator, in the center are some of the coils and at the right is a stator partly wound. The coil ends are not taped but are insulated with triangular pieces of treated cloth, as already described. Fig. 7 shows how the throw coils on this or any other type of winding may be tied back out of the way to allow the last coils to be put in the bottom of the slots.

Fig. 9—How strap-copper coils are put into the slots.
The figures on the straps indicate the order of placing them in the slot.

When winding any type of stator the less pounding that is done to shape the coil, the better. It is the duty of the coil department to furnish coils of the right size. They should not be smaller than the old sample coil, a little larger, if anything. With a proper size and shape of coil very little pounding is required, only a light tap at the nose of the coil and on the sides of the ends.

Threaded-In Strap-Copper Coils

There are some stators having partially closed slots which are wound with coils made of strap copper. Fig. 9 illustrates the methods of putting such coils in the slots. At *c* is shown a three-turn coil with the slot opening in the center and just wide enough to pass one strap at a time. The numbers on each strap in the drawing indicate the order in which they are put in. At *a*, strap No. 1 is put in and pushed over to the left as far as it will go. Then No. 2 is put in and pushed to the right, after which No. 3 is forced between 1 and 2 as at *b*.

At *d* is shown a two-turn coil in an overhanging slot. Bar No. 1 is put in and forced under the overhang of the tooth and then No. 2 is forced down straight. At *c* is a two-turn coil with the opening in the middle of the slot. The last strap has to be inclined a bit to get it in.

Articles to be published later on the types of winding outlined herein will explain the details of figuring the number of coils per group, including odd groupings and how to stub coils and connect windings.

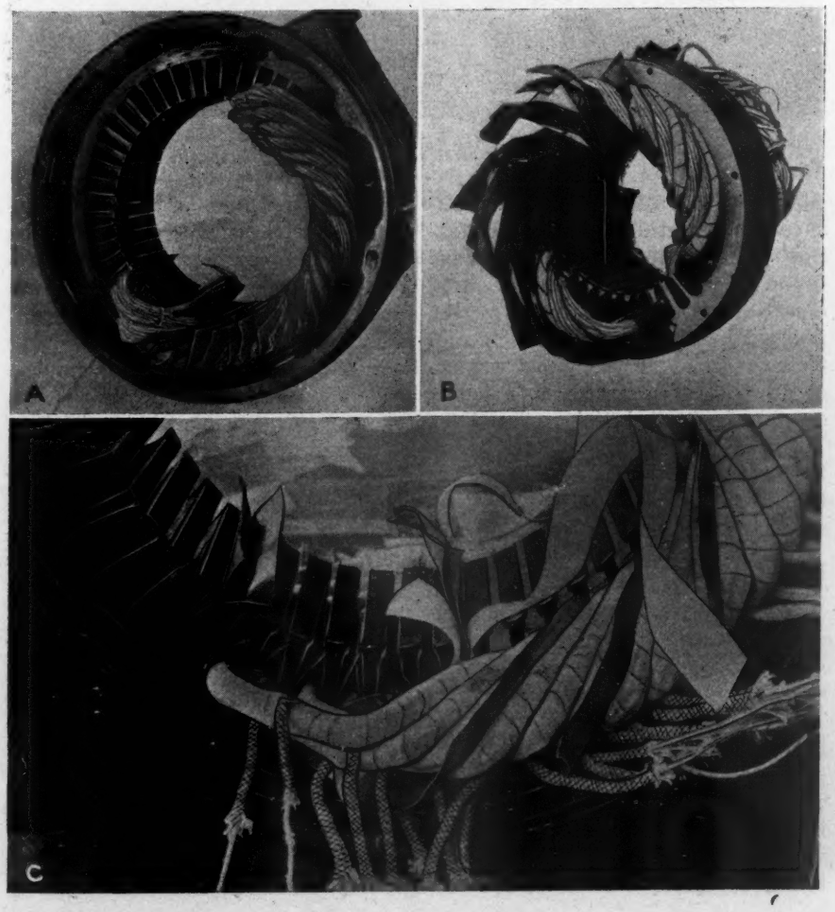


Fig. 8—Two-layer windings with flat diamond mush coils.
At *A* none of the coils are taped. They are insulated from each other at both ends by treated-cloth triangles under every coil. At *B* the treated-cloth triangles are used and in addition one coil out of every three is taped to afford extra protection between phases. At *C* all of the coils are taped and treated-cloth triangles are inserted at every point where two phases come together. At the left of the last coil a slider is shown ready to receive the bottom side of the next coil to be inserted. Near the center is shown a slider ready to receive the top side of the coil. A strip of 1-in. cotton tape is inserted under the end of this slider, projecting about ⅛ in. out of the slot. After the coil and wedge are put in, this tape is used to make a sealed insulating joint slider, wedge and coil.

A Correction

THIS opportunity is taken to thank several readers for calling attention to an error in the table of the "Capacity of Roof Ventilators" which appeared on page 371 of the August issue of INDUSTRIAL ENGINEER. The headings on the columns of capacity should have read "Cu. ft. per Hour" instead of Cu. ft. per Min.," as given in this article.

THE RUGGEDNESS of modern electrical equipment cannot prevent occasional failure under the stresses produced by heavy overloads, the mistakes or carelessness of operators, or some of the many mishaps which may occur to any equipment from natural wear and tear. In this article Mr. Spencer tells how the losses sustained in consequence of such failure may be fully covered by insurance policies.

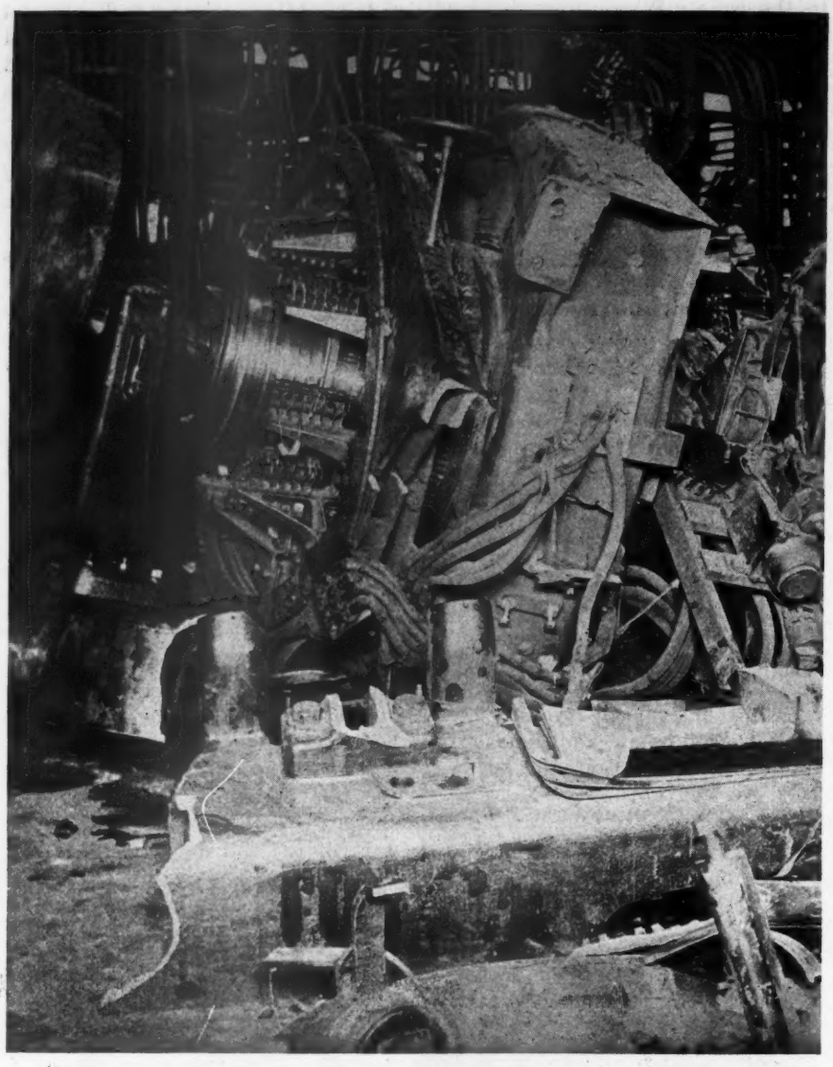
Protection From Loss by

Breakdown of Electrical Equipment

And Extent of Coverage That Is Afforded by Insurance Policies

By B. K. SPENCER

Electrical Engineer, The Travelers Indemnity Co., Hartford, Conn.



Wreck of motor-generator set after a short-circuit and subsequent explosion

IN AN industrial works where electrical energy is the source of the power, light and perhaps heat required in the manufacturing processes, the failure of an important piece of equipment may result in serious financial loss. The cost of putting the damaged equipment again into service may amount to many hundreds of dollars, but it is frequently equaled or even exceeded by the loss occasioned through the stopping of production and damage to parts or materials in process. The wide use of electrical energy for industrial purposes has, therefore, created a demand for a large number of new devices and also for an insurance policy that will protect the assured, the owner of these devices, from losses resulting from their failure.

When we determined to write such insurance, it was decided at the outset that the coverage on this policy must be of the very broadest possible sort in order to give the assured no opportunity for dissatisfaction in connection with it. We have found in the past that the greatest dissatisfaction on the part of the assured has been because of incomplete coverage. Every effort was accordingly made to present a policy devoid of so-called "jokers," and the result is a policy which is probably the broadest of any policy form written at the present time.

Payment of Indemnity Is Not Determined by Cause of Accident

In order to approach the ideal condition of complete coverage which has long been considered so desirable by insurance companies, The Travelers decided upon a combination policy form known as the Machinery Policy. In this policy any electrical machines may be insured in the same contract with steam engines, steam turbines, water turbines, flywheels and so on. Under electrical machines any type of electrical apparatus with the exception of lightning arresters, lifting magnets, heating elements, electric lamps, magnetic chucks, batteries and vacuum tubes may be insured. The assured wants absolutely complete coverage and this policy affords him as nearly as possible what he is after.

Under the contract an agreement is made to indemnify the assured by payment to him or in his behalf in the event of an accident to any machine insured, for loss or damage to the machine or other property of the assured for which he is legally liable. Liability for injury to public or employees may also be covered, if so desired. Any "sudden, substantial and accidental breaking, burning out or disrupting" of the machine or any part of it which immediately necessitates shut-down of the machine, is termed an accident.

A little reflection will show that this policy is even breader than it

appears at first sight, because there is no mention of *causes* and the coverage is not, therefore, limited by causes. Of course, this policy does not contemplate payment of losses while machines are being operated in an extraordinary manner, such as on test; nor does it pay for losses which are specifically covered by other recognized forms of policy, such as fire, inundation, strike, riot or civil commotion. There would be no advantage in making a policy as broad as that. As it is the policy covers not only complete loss of the machine or a catastrophe, but also all burn-outs whether complete or partial and innumerable small breaks which are usually repaired by the assured's own men and which, therefore, constitute no extra expense, but nevertheless must increase the maintenance account. These accidents are considered as maintenance by the assured and in most cases constitute a large part of the total maintenance expense. Protection by an accident policy, therefore, relieves the assured of a portion of this expense.

In addition to the above there can be had special coverage known as Use and Occupancy, Consequential Loss, and Deductible Liability. Use and Occupancy is provided at an extra premium to indemnify the assured for complete or partial loss of production resulting from an accident to any of the machines listed in the policy and operated by the assured. It also covers the suspension of operation in his plant resulting from the kind of accident contemplated to any or all electrical machinery supplying such power. Indemnity is furnished up to a certain limit for each day of suspension of operation, and this indemnity may run for 100, 200, 400 or more days' duration, depending upon the amount of insurance purchased. It may also commence on the eighth midnight after the accident or at a previous date, depending on the amount of premium paid. Consequential Loss provides indemnity, at an additional premium, against indirect loss resulting from an accident to the electrical machinery insured. The direct damage policy furnishes protection against all damage resulting directly from an accident or in a continuous sequence of physical events, but when an accident sets up a new condition of affairs and as a result of this condition further damage eventually results, such as the freezing of flowers in a greenhouse, due to a boiler explosion, this is called indirect damage or consequential loss. Deductible Liability allows a considerable reduction in premium providing the assured agrees to pay the first $50, $100 or other amount of any loss to his machines. Any loss exceeding the deductible liability is paid for by the insurance company.

Examples of Accidents to Electrical Equipment

To illustrate the ease with which accidents may occur and the breadth of coverage under our policy, I would like to cite one or two incidents of damage brought about by various insignificant causes and by conditions which are found very commonly.

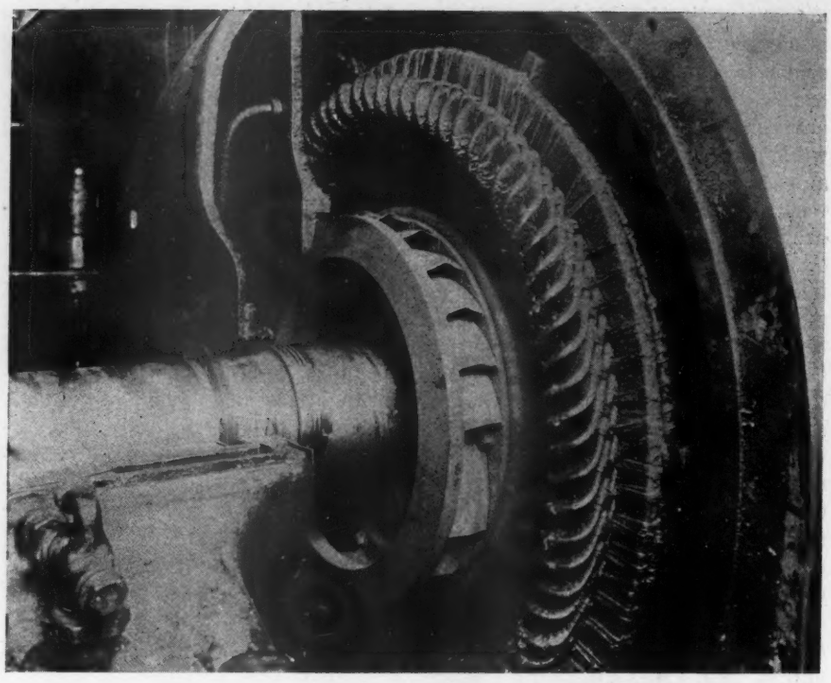
A certain electrical system in a large city was composed of several power stations, sub-stations and various industrial plants. All of these units were connected together by transmission lines, with transformers at the industrial plants to reduce the voltage. A regular routine of inspection was in force, but evidently the inspector on one of his trips failed to notice a loose contact on a disconnecting switch. This loose contact caused the switch to heat and thus increased the resistance until finally the switch became red-hot and began to arc. The arcing set up disturbances in the way of high frequency surges which were immediately transmitted to all parts of the system.

Before the trouble was discovered and the operators realized the severity of the situation, the whole system was upset by violet fluctuations in the voltage and current, with the result that several motors in one industrial plant and other equipment in the power and substations was burned out with a loss of several thousand dollars.

In one plant several special motors were installed in addition to a good deal of other equipment. These motors are called the multi-speed type

A variety of damaged equipment waiting for the repairman.

At the left, a transformer disassembled for repair. A corner in the repair shop of a large industrial works, on the right, shows the miscellaneous nature of this work.



This generator was put out of commission by the breaking away of part of the frame.

and have three separate windings, all connected by wiring to controllers for regulating the speed. It was supposed that the contractors were sufficiently reliable to install this equipment without any danger of trouble later on, and in fact other reliable contractors might have done the same as they did, because of the extreme care necessary in installing the motors. At any rate, it was found on starting these motors that the operator frequently left the controller slightly off the notch in such a way that a short-circuit occurred and on several occasions severe damage resulted to the windings. One motor was burned out four times before the trouble was definitely located and the proper remedy applied.

In an industrial plant having nearly 200 small motors, a very serious loss occurred recently due to the breaking down of the insulation in the transformers of an outside company from which power was purchased. Energy was taken from transmission lines passing the property and the voltage reduced by means of transformers in an outdoor sub-station. This installation represented the very best modern engineering practice and was supposedly well protected, but a high frequency surge, overload or something caused the transformer to break down and burn out, and in the process 13,000 volts were impressed on the secondary circuit and proceeded to run riot, picking out various machines without regard to their physical location on the lines and burning out their windings. On several of the 22 machines burned out, the laminated iron core was so badly burned and pitted that entire replacement of the machine was necessary.

In another plant similar to that mentioned above, the owners have struggled for years with a mysterious and baffling problem which has caused thousands of dollars in losses to them. They are only now beginning to get control of the situation and they actually do not know now just what the remedy has been. They only know that innumerable experiments have been resorted to and the losses are now very infrequent, while the "symptoms" have disappeared. The principal symptoms were needle-point punctures of the insulation on most but not all of the machines at regular intervals around the windings, with severe sparking and flashing on the windings at certain periods of starting. Some of the remedies resorted to were improvement of the grounding system, changes in motor starters, regulation of voltage and even the reconnecting and dividing of the load on the transformers supplying the power in order to change the impedance of the connections.

Insurance Rates Were Based on Careful Study of Operating Records

The cases mentioned do not begin to touch on the various causes of accidents. Every operating engineer will testify that almost no two accidents are the same in dealing with electrical equipment. Each accident is a separate and distinct problem in itself so far as the determination of the specific cause of the trouble is concerned. In the majority of cases the cause remains more or less a mystery, and the most it is possible to do is to get an idea as to the general nature of the trouble. Surges on the line, lightning, breakdown of insulation, overloads, high and low voltage, starting strains and synchronizing, loosening of the coils and parts of the machines and the mechanical failure of the rotor are a few things which may result sooner or later in breakdowns, burnouts or complete disruption of the unit.

In order to insure all classes of electrical equipment and to determine the correct rates for each, it was necessary for our engineers to make a detailed study in co-operation with other engineers, for the purpose of arriving at a rate which was adequate and yet not excessive. Insurance rates should be based on insurance experience, but lacking this, the next best thing was to take actual operating experience over as broad a spread as we could possibly obtain, and use it as a basis. About a year was spent on this work and a very large volume of experience was recorded. A questionnaire form was made out and sent to all classes of operating companies and they gave us a record of the different machines in operation, the length of time operated, number of accidents, extent of loss, and so on. By collecting this data, analyzing it and drawing up curves, we were able to determine a loss frequency and extent of loss for all different classes of equipment. It is not sufficient merely to reflect the probable extent of loss for one accident; it is necessary also to reflect the probable loss frequency. Some machines break down frequently, but all of the losses are small; others run along for years, but when they do fail the result is disastrous. It was necessary, therefore, that the rates reflect all conditions and it is believed that this was accomplished. It is not possible to go into all the details of arranging the losses or the method of calculating the rates, but it may be said that a great deal of time was spent in try-

ing to simplify the method of rating without sacrificing its flexibility and accuracy.

Everything about the rating system was arranged and laid out just as one would lay out a power plant with the idea of allowing for future expansion. The more common types of machines were arranged in a Classification Schedule, as shown, generators, motors, transformers, and so on, of different kinds of currents and different voltages being given certain classification numbers. These numbers refer to different classification tables in which the insurance rate varies about 10 per cent per table. In other words, starting with Table 10 as a basis, Table 11 was made by increasing the rates about 10 per cent.

In the classification tables referred to above there are given insurance rates for machines of different capacities and different speeds. There are two steps to be taken in obtaining these rates; first we take the Object Rate and to that add an insurance rate which is one per cent for each $1,000 of insurance applying to the machine in question. The Object Rate reflects the hazard of different types and capacities of machines on account of their varying costs of replacement and the Insurance Charge reflects the additional hazard on account of excessive limits of insurance, which of course increases the company's liability, for possible damage to surrounding property. If public or employees are covered there is another charge which must be added, and for each risk, regardless of the number of machines operated, we have a location charge of a few dollars.

At the present time miscellaneous equipment such as switchboards, feeder regulators, oil switches, reactor coils, and so on, are placed in a group called Miscellaneous Non-Rotating Equipment, but just as fast as it is possible to obtain the necessary insurance experience on this equipment it will be specifically rated, placed in the classification schedule and given a classification table number. In this way the rate may be adjusted for different classes of machinery and for different conditions of operation so that one class of equipment will not suffer from higher rates on account of poor experience on another class. For instance, it may be necessary to increase our rates for oil switches, but that will not necessarily increase rates for motors or generators; in fact, it may be found possible to decrease these rates.

A statistical system has been worked out and is being followed very closely on all risks, so that after two or three years' experience it will be possible to tell exactly what the rate should be for all classes of apparatus, all conditions of operation, all types of plants, all geographical locations and so forth. In the future, as the volume of business increases and losses accumulate, insurance experience can be drawn from the records and the rates revised as needed. From the indications of the last six months, however, it is probably safe to say that very little revision will be needed in the rates of most types of apparatus.

Classification Schedule Showing Principal Divisions Only

- **Generators**
  - Alternating Current
    - 5,000 volts or less
    - Over 5,000 volts
  - Direct Current
    - 300 volts or less
    - 301 to 750 volts
    - 751 to 1,500 volts
    - Over 1,500 volts
- **Motors**
  - Alternating Current
    - 750 volts or less
    - 751 to 5,000 volts
    - Over 5,000 volts
  - Direct Current
    - 300 volts or less
    - 301 to 750 volts
    - 751 to 1,500 volts
    - Over 1,500 volts
- **Rotary Converters**
  - D. c. voltage 300 or less
  - D. c. voltage 301 to 750
  - D. c. voltage 751 to 1,500
  - D. c. voltage over 1,500
- **Transformers**
  - Single-phase
    - 2,400 volts or less
    - 2,401 to 6,600 volts
    - 6,601 to 22,000 volts
    - Over 22,000 volts
  - Three-phase
    - 2,400 volts or less
    - 2,401 to 6,600 volts
    - 6,601 to 22,000 volts
    - Over 22,000 volts

Engineering and Inspection Service Helps to Prevent Accidents

As the number of users of electrical energy increases, a larger number of inexperienced operators are encountered and the number of accidents from causes which can be controlled by instructive literature and recommendations resulting from inspections likewise increases. Small and medium-size users of electricity often buy equipment from the manufacturers and take it for granted that this equipment is made "fool-proof," so that all they have to do is to connect it up with a few wires and throw in a switch, and forever after obtain power in unlimited quantities without any trouble whatsoever. Sometimes they are fortunate and have very little, if any, trouble, but usually they have a large number of accidents and immediately try to place the blame on the manufacturer. In this connection, I wish to emphasize the need of co-operation on the part of the manufacturer in this new line of insurance. Our policy covers all accidents, regardless of whether these are caused by faulty construction and materials, and for this reason it protects the manufacturer against unreasonable demands by a customer for payment of losses which are due entirely to poor operating conditions. There is every reason to hope for this co-operation and it is already being received to some extent.

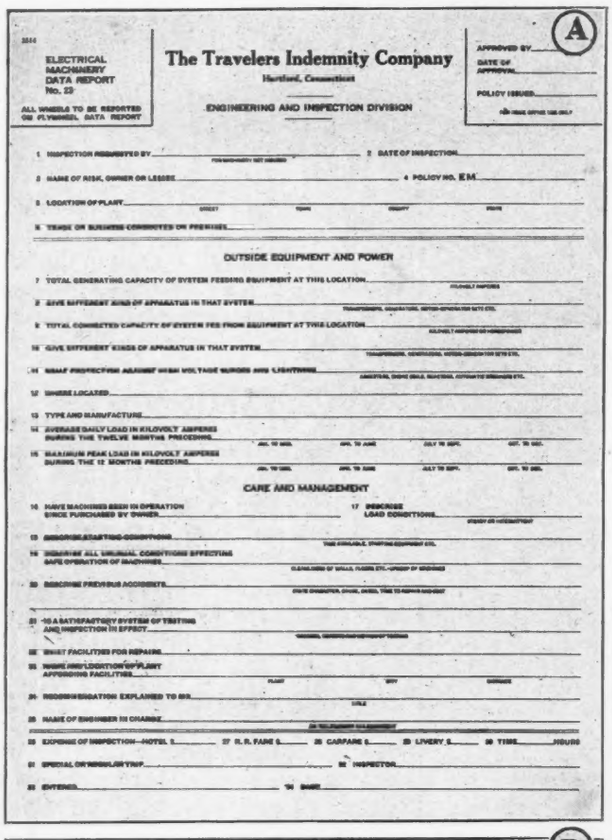
One class of accidents is referred to above and consists of those due to neglect or ignorance on the part of the operator. There are other classes of accidents, however, which are almost, if not quite, uncontrollable. In this class come burnouts and breakdowns caused by lightning, surges on the line, operators' mistakes during periods of extreme stress and similar mishaps. Such accidents require an entirely different scheme of treatment, but it is felt that their frequency can be reduced.

Most persons are more or less familiar with the service which is granted under our Boiler Policy, and it is generally agreed that this service is of inestimable value to the assured and in some cases of even more value than the protection afforded by the policy. In many cases boilers are insured for the inspection service alone. There is quite a difference of opinion among various insurance companies as to what form the engineering and inspection service should take in the case of electrical machinery, but, of course, I can only cite what The Travelers' plan is in this respect.

Boiler engineering and inspection service is a mechanical proposition and our problem is really to satisfy our engineering requirements either by specification, supervision of man-

Insurance Inspectors' Report Sheets

The fronts and backs of the two sheets A and C make a continuous record, the sections reading in the order shown



A

ELECTRICAL MACHINERY DATA REPORT No. 23

ALL WHEELS TO BE REPORTED ON FLYWHEEL DATA REPORT

The Travelers Indemnity Company
Hartford, Connecticut
ENGINEERING AND INSPECTION DIVISION

APPROVED BY
DATE OF APPROVAL
POLICY ISSUED

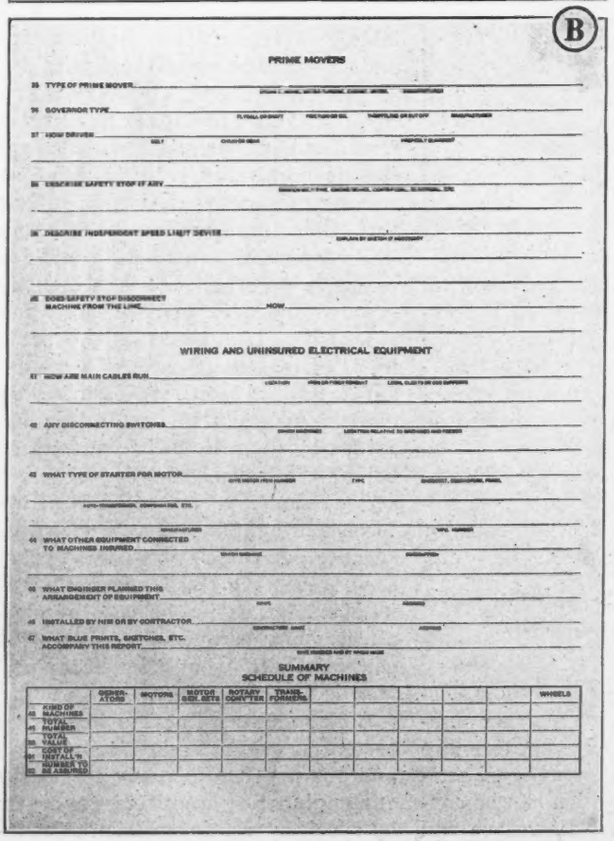
1 INSPECTION REQUESTED BY 2 DATE OF INSPECTION
3 NAME OF RISK, OWNER OR LESSEE 4 POLICY NO. E.M.
5 LOCATION OF PLANT (STREET, TOWN, COUNTY, STATE)
6 TRADE OR BUSINESS CONDUCTED ON PREMISES

OUTSIDE EQUIPMENT AND POWER

7 TOTAL GENERATING CAPACITY OF SYSTEM FEEDING EQUIPMENT AT THIS LOCATION (KILOWATTS OR KVA)
8 GIVE DIFFERENT KIND OF APPARATUS IN THAT SYSTEM (TRANSFORMERS, GENERATORS, MOTOR-GENERATOR SETS ETC.)
9 TOTAL CONNECTED CAPACITY OF SYSTEM FED FROM EQUIPMENT AT THIS LOCATION (KILOWATTS, HORSEPOWER OR HORSEPOWER)
10 GIVE DIFFERENT KINDS OF APPARATUS IN THAT SYSTEM (TRANSFORMERS, GENERATORS, MOTOR-GENERATOR SETS ETC.)
11 BRIEF PROTECTIVE AGAINST HIGH VOLTAGE SURGES AND LIGHTNING (ARRESTERS, SPARK GAPS, REACTORS, CUTOUTS TO GROUNDED ETC.)
12 WHERE LOCATED
13 TYPE AND MANUFACTURE
14 AVERAGE DAILY LOAD IN KILOVOLT AMPERES DURING THE TWELVE MONTHS PRECEDING (JAN. TO MAR., APR. TO JUNE, JULY TO SEPT., OCT. TO DEC.)
15 MAXIMUM PEAK LOAD IN KILOVOLT AMPERES DURING THE 12 MONTHS PRECEDING (JAN. TO MAR., APR. TO JUNE, JULY TO SEPT., OCT. TO DEC.)

CARE AND MANAGEMENT

16 HAVE MACHINES BEEN IN OPERATION SINCE PURCHASED BY OWNER 17 DESCRIBE LOAD CONDITIONS (STEADY OR INTERMITTENT)
18 DESCRIBE STARTING CONDITIONS (TIME REQUIRED, STARTING EQUIPMENT ETC.)
19 DESCRIBE ALL UNUSUAL CONDITIONS EFFECTING SAFE OPERATION OF MACHINES (CLEANLINESS OF WALLS, FLOORS ETC.—SPEED OF ENGINES)
20 DESCRIBE PREVIOUS ACCIDENTS (STATE CHARACTER, CAUSE, DATES, TIME TO REPAIR AND COST)
21 IS A SATISFACTORY SYSTEM OF TESTING AND INSPECTION IN EFFECT (METHOD, DEGREE AND FREQUENCY OF TESTING)
22 WHAT FACILITIES FOR REPAIRS
23 NAME AND LOCATION OF PLANT APPEARING FACILITIES (PLANT, CITY, DISTANCE)
24 REGARDING EDUCATION EXPLAINED TO (NAME, TITLE)
25 NAME OF ENGINEER IN CHARGE (IF NOT PRESENT GIVE ADDRESS)
26 EXPENSE OF INSPECTION—HOTEL $ 27 R. R. FARE $ 28 CARFARE $ 29 LIVERY $ 30 TIME HOURS
31 SPECIAL OR REGULAR TRIP 32 INSPECTOR
33 ENTERED '34 BY



B

PRIME MOVERS

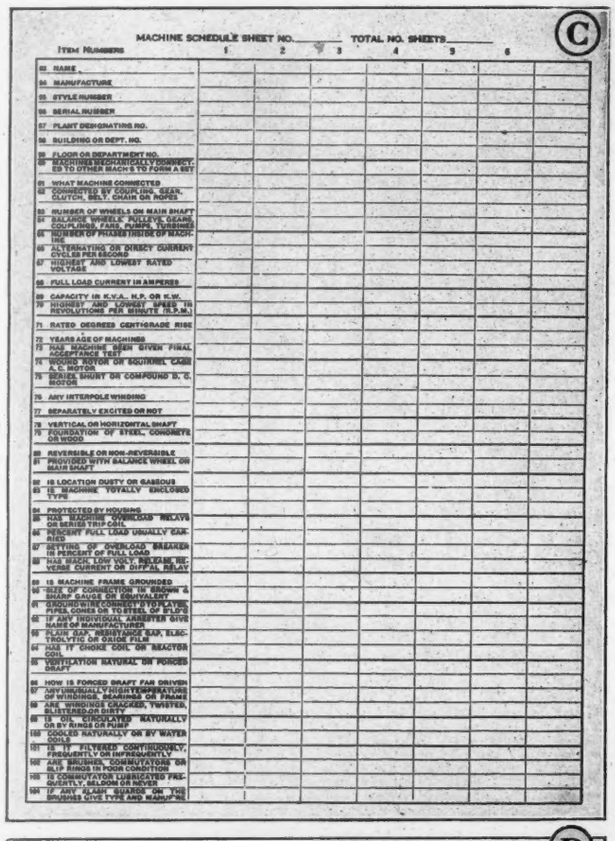
35 TYPE OF PRIME MOVER (STEAM E. ENGINE, WATER TURBINE, GASOLINE ENGINE, MANUFACTURER)
36 GOVERNOR TYPE (FLYBALL OR SHUNT, FRICTION OR OIL, THROTTLING OR SLIT OIL, MANUFACTURER)
37 HOW DRIVEN (BELT, CHAIN OR GEAR, PRINCIPAL CHARACTER)
38 DESCRIBE SAFETY STOP IF ANY (EMERGENCY VALVE, ENGINE MEANS, CONTROLLER, OIL SWITCH, ETC.)
39 DESCRIBE INDEPENDENT SPEED LIMIT DEVICE (EXPLAIN BY SKETCH IF NECESSARY)
40 DOES SAFETY STOP DISCONNECT MACHINE FROM THE LINE (HOW)

WIRING AND UNINSURED ELECTRICAL EQUIPMENT

41 HOW ARE MAIN CABLES RUN (LOCATION, FROM OR THROUGH WHAT, LOCAL CLEARANCES)
42 ANY DISCONNECTING SWITCHES (WHERE LOCATED, LOCATION RELATIVE TO MACHINES AND FEEDER)
43 WHAT TYPE OF STARTER FOR MOTOR (GIVE MOTOR FROM WHICH, TYPE, MANUFACTURER, MANUFACTURERS NAME, AUTO-TRANSFORMER, COMPENSATOR, ETC.)
44 WHAT OTHER EQUIPMENT CONNECTED TO MACHINES INSURED (WHICH MACHINE, DESIGNATION)
45 WHAT ENGINEER PLANNED THIS ARRANGEMENT OF EQUIPMENT (NAME, ADDRESS)
46 INSTALLED BY HIM OR BY CONTRACTOR (CONTRACTORS NAME, ADDRESS)
47 WHAT BLUE PRINTS, SKETCHES, ETC. ACCOMPANY THIS REPORT (GIVE NUMBERS AND BY WHOM MADE)

SUMMARY
SCHEDULE OF MACHINES

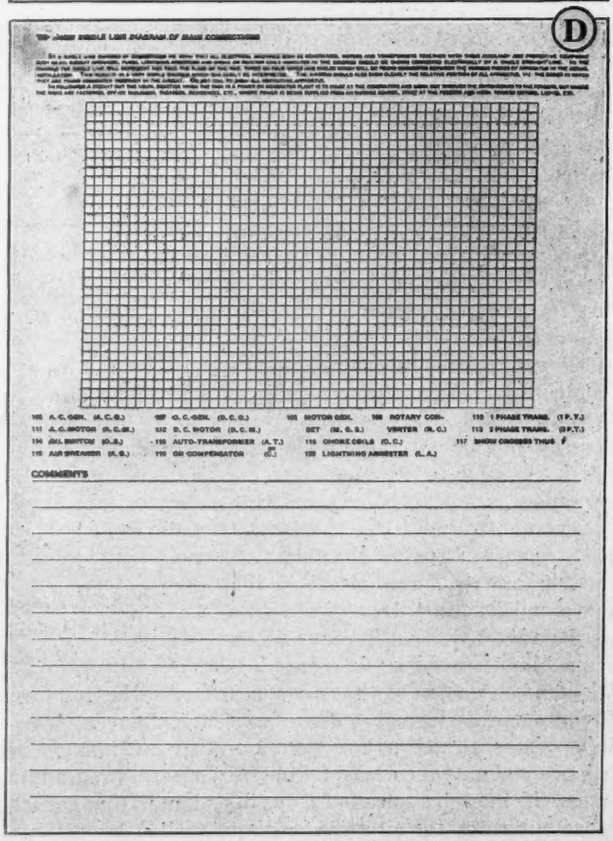
	GENERATORS	MOTORS	MOTOR GEN. SETS	ROTARY CONVTER	TRANSFORMERS						WHEELS
48 KIND OF MACHINES											
49 TOTAL NUMBER											
50 TOTAL VALUE											
51 COST OF INSTALLN											
52 NUMBER TO BE ASSURED											



C

MACHINE SCHEDULE SHEET NO. TOTAL NO. SHEETS

ITEM NUMBERS	1	2	3	4	5	6
53 NAME						
54 MANUFACTURE						
55 STYLE NUMBER						
56 SERIAL NUMBER						
57 PLANT DESIGNATING NO.						
58 BUILDING OR DEPT. NO.						
59 FLOOR OR DEPARTMENT NO.						
60 MACHINES ERGONOMICALLY CONNECTED TO OTHER MACHINES TO FORM A SET						
61 WHAT MACHINE CONNECTED						
62 CONNECTED BY COUPLING, GEAR, CLUTCH, BELT, CHAIN OR ROPES						
63 NUMBER OF WHEELS ON MAIN SHAFT						
64 BALANCE WHEELS, PULLEYS, GEARS, COUPLINGS, FANS, PUMPS, TURBINES						
65 NUMBER OF PHASES INSIDE OF MACHINE						
66 ALTERNATING OR DIRECT CURRENT CYCLES PER SECOND						
67 HIGHEST AND LOWEST RATED VOLTAGE						
68 FULL LOAD CURRENT IN AMPERES						
69 CAPACITY IN K.V.A., H.P. OR K.W.						
70 HIGHEST AND LOWEST SPEED IN REVOLUTIONS PER MINUTE (R.P.M.)						
71 RATED DEGREES CENTIGRADE RISE						
72 YEARS AGE OF MACHINES						
73 HAS MACHINE BEEN GIVEN FINAL ACCEPTANCE TEST						
74 WOUND ROTOR OR SQUIRREL CAGE A. C. MOTOR						
75 SERIES, SHUNT OR COMPOUND D. C. MOTOR						
76 ANY INTERPOLE WINDING						
77 SEPARATELY EXCITED OR NOT						
78 VERTICAL OR HORIZONTAL SHAFT						
79 FOUNDATION OF STEEL, CONCRETE OR WOOD						
80 REVERSIBLE OR NON-REVERSIBLE						
81 PROVIDED WITH BALANCE WHEEL ON MAIN SHAFT						
82 IS LOCATION DUSTY OR GASEOUS						
83 IS MACHINE TOTALLY ENCLOSED TYPE						
84 PROTECTED BY HOUSING						
85 HAS MACHINE OVERLOAD RELAYS OR SERIES TRIP COIL						
86 PERCENT FULL LOAD USUALLY CARRIED						
87 SETTING OF OVERLOAD BREAKER IN PERCENT OF FULL LOAD						
88 HAS MACH. LOW VOLT. RELEASE, REVERSE CURRENT OR DIFFAL RELAY						
89 IS MACHINE FRAME GROUNDED						
90 TEST OF CORRECTION IN KNOWN A SHARP GAUGE OR CRITICAL VOLT.						
91 GROUNDING CONNECTIONS TO WATER PIPES, CONDS OR TO STEEL OF FLOOR						
92 IF ANY INDIVIDUAL ARRESTER GIVE NAME OF MANUFACTURER						
93 PLAIN GAP, RESISTANCE GAP, ELECTROLYTIC OR OXIDE FILM						
94 HAS IT CHOKE COIL OR REACTOR COIL						
95 VENTILATION NATURAL OR FORCED DRAFT						
96 HOW IS FORCED DRAFT FAN DRIVEN						
97 ANY UNUSUALLY HIGH TEMPERATURES OF WINDINGS, BEARINGS OR FRAME						
98 ARE WINDINGS CRACKED, TWISTED, BLISTERED OR DIRTY						
99 IS OIL CIRCULATED NATURALLY OR BY RINGS OR PUMP						
100 COOLED NATURALLY OR BY WATER COILS						
101 IS IT FILTERED CONTINUOUSLY, FREQUENTLY OR INFREQUENTLY						
102 ARE BRUSHES, COMMUTATORS OR SLIP RINGS IN POOR CONDITION						
103 IS COMMUTATOR LUBRICATED FREQUENTLY, SELDOM OR NEVER						
104 IF ANY FLASH GUARDS ON THE BRUSHES GIVE TYPE AND MANUFR.						



D

THE SINGLE LINE DIAGRAM OF MAIN CONNECTIONS

105 A. C. GEN. (A. C. G.) 107 D. C. GEN. (D. C. G.) 109 MOTOR GEN. 109 ROTARY CON- 110 1 PHASE TRANS. (1 P. T.)
111 A. C. MOTOR (A. C. M.) 112 D. C. MOTOR (D. C. M.) VERTER (R. C.) 113 3 PHASE TRANS. (3 P. T.)
114 OIL SWITCH (O. S.) 115 AUTO-TRANSFORMER (A. T.) 116 CHOKE COILS (C. C.) 117 SHOW CROSSES THUS
118 AIR BREAKER (A. B.) 119 OR COMPENSATOR (C.) 120 LIGHTNING ARRESTER (L. A.)

COMMENTS

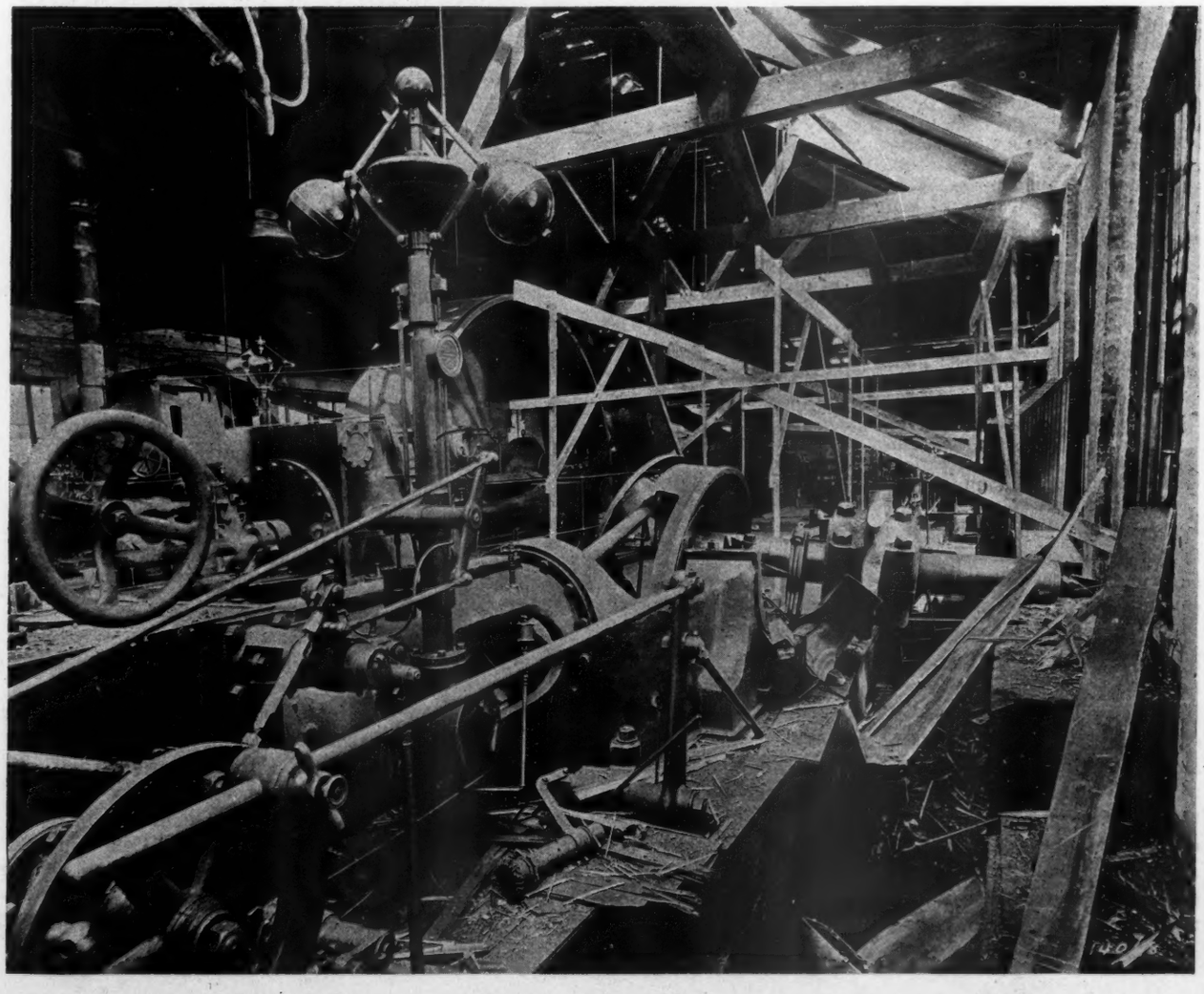
ufacture and finally test in the shop, or by a rigid inspection by trained men under actual operating conditions, and recommendations which will bring the boiler up to our engineering standard from a mechanical viewpoint. Care and management is very important, of course, but it is not given as much weight as in electrical machinery insurance.

Inspections Set a Good Example for Operators

With electrical machinery the proposition is entirely different. A motor or a generator is a mechanical as well as an electrical machine, to be sure, but the best make of motor or generator, if put into operation and subjected to poor operating conditions, dust, gas, heavy starting duty, overloads, or otherwise abused, is no more immune to trouble than a poor grade machine. There are innumerable things to be considered not only as regards the manufacturer of the equipment, but also the operating conditions, care and management and so on. In other words, our service in this line is mainly an engineering problem and not to such a degree a question of inspection of the mechanical condition of individual machines.

By this I do not mean to imply that we do not give inspection service. Inspections several times a year are valuable, not because they keep the machines from breaking down, but because they set a good example to the operators and operating engineers and create an incentive to better operating conditions. We call this the improvement of the moral hazard. Tests of machines and detailed inspections from a mechanical standpoint are valuable only in so far as they teach the operators themselves to do the same sort of inspecting at much more frequent intervals. Most plants require inspection of some of the equipment at least every day; other inspections must be made weekly or monthly. Our problem is to give the assured engineering service, but not to the extent of performing the actual installation and test of his equipment. In this respect we are like the consulting engineer who is called in by a client, makes a thorough investigation of his equipment, operating conditions and the like, but does no more than report on conditions, write specifications and supervise the changes. The client must arrange for the rest. Similarly, our engineering service takes the form of a survey and analysis, with recommendations, after writing the business, which will tend to improve the general conditions surrounding the risk and to reduce the number and extent of the losses.

One of our big problems in this line is to keep the good will of the assured and all employees of the assured to the extent that they will be anxious to co-operate with our inspectors and carry out the suggestions sent them by correspondence. In this way real results can be obtained. No matter how good our inspection (*Continued on page* 507)



This engine was so completely wrecked that it was hardly worth repairing.

Two workmen were killed and considerable damage was done to the building and nearby equipment.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT E. H. HUBERT F. E. GOODING

Chicago, October, 1922

Mortality of Lamps in A. C. and D. C. Service

SOME interesting comments on this subject were presented by John W. Lieb in a paper presented early this month before the Illuminating Engineering Society. Mr. Lieb pointed out that definite information on filament fragility is entirely of laboratory origin. He said:

> It is known that all tungsten filament lamps are relatively sturdy when new, but become fragile after some hours of operation and increase in fragility thereafter as they are burned. This effect is accelerated if the lamps are subjected to vibration or jar. Perhaps the most reliable indication of fragility is that deduced from the operation upon stationary racks supplied with respectively 60-cycle current and direct-current, and afforded by filament breakage in incidental handling for photometric testing of lamps which are being life-tested. * * * Among the Mazda B lamps the mortality rates are quite similar for the first 800 hours, after which failures among lamps on alternating current occur with increasing frequency, while the mortality rate does not change much throughout on direct current. Among the 100-watt Mazda C lamps, those operated on direct current are characterized by more failures during the first 900 hours and subsequently by a lower rate of failure.
>
> The statistics of these failures, classified in 200-hour periods, with data adjusted to efficiencies necessary to yield a total life of 1,000 hours upon 60-cycle current, show a greater concentration of failures between 600 and 1,200 hours among lamps operated upon alternating current with fewer relatively long lived lamps.

While only relative and comparable laboratory performance of tungsten lamps in alternating and direct current service is given, the information emphasizes the importance of paying attention to lamp life in a large works where thousands of lamps are used. If lamps are not giving an average of better than 600 hours' service, this is evidently an indication that an investigation with the aid of a lamp specialist of one of the lamp manufacturers would save a considerable sum through the adjusting of the lighting installation to make it better suited to the particular conditions that may be present. Too frequently comparisons for corresponding periods of lighting bills and costs of new lamps replaced are the only check given on lamp service in industrial works. A survey of lamp life and an analysis of the entire lighting installation may mean far better lighting at no more and probably less cost through correcting the conditions that reduce lamp life and crediting this waste to the cost of light energy actually required and used.

Production Insurance— What Is It?

THERE is a lot of production insurance that goes under some other and more confusing name. For instance, in a steel mill rolling rails the stopping of the driving motor and the chilling of the metal calls for some fast work with considerable loss under the best of conditions. Likewise when the fuses of a crane motor blow with a ladle of hot metal on the hook, the reheating of this and the time lost represents a definite and measureable waste. In both these cases the insurance against this waste comes back to the thing that breaks the circuit, the lack of it in an adequate type or inadequate inspection of the motor service.

In one plant where production insurance is provided by the best of engineering thinking in the installation of equipment and the inspection and maintenance of it in operation, something like $750 worth of spare parts are kept on hand for every five-ton hoist that is used. This is insurance at the rate of about 30 cents an hour for eight hours of operation every day in the year without service interruptions that will show a handsome return on the money invested if more than two interruptions are prevented in a 12-month period, where the hoists are used in keeping up a uniform flow of products in production at machines. This familiar bit of wisdom, "a stitch in time saves nine," is a good interpretation of production insurance.

What and Where Are Your Fire Hazards.

THE losses occasioned in this country by fire amount to hundreds of millions of dollars annually and constitute one of our largest and most serious sources of economic and industrial waste.

Fire is an ever-present danger in every industrial works and can cause as much or more damage and loss than any accident or mishap that is ordinarily encountered. One reason for this is that while the loss from the actual destruction of property by fire may be large, the incidental or indirect losses are frequently just as large, or even greater. The damage caused by water, heat or smoke to materials and equipment, the stoppage of production, with the consequent loss of business through inability to fill orders and, finally, the disruption of the organization which inevitably follows any prolonged shutdown, are some of the expensive accompaniments of a bad fire.

Largely in memory of the great Chicago fire, October has come to be known as fire prevention month, and unusual attention is paid in the daily press, the publications of various associations and otherwise to the importance of paying attention to precautions that will reduce fire hazards as much as possible.

From one standpoint at least this month is particularly appropriate for such a campaign. Cold weather is only a few weeks off, and although fire hazards, on the whole, may not be much if any greater during the winter months, snow, ice and freezing weather delay

and make much more difficult the work of the fire-fighters. In consequence, fires in the winter time are liable to be much more disastrous.

Fires are not, however, prevented by legislation or resolutions. Effective measures include the location and study of unusual hazards, with the object of minimizing them as much as possible, the prompt removal of inflammable waste or refuse and, in general, rigid observance of the requirements prescribed by insurance companies and city ordinances.

There's a Reason for Every Misfit

ANYONE can place an order for a motor or switchboard from a catalog number, but the intelligent selection of electrical equipment in general is a matter which often requires more care and study than it is accorded. The extensive use of electric service in industrial works has called for the application of motors and other equipment under practically every conceivable condition of service. As a result of this demand there has been developed a wide variety of equipment built to meet special conditions and needs, and new designs are constantly being placed on the market. The purchaser of equipment is, therefore, confronted with the task of selecting from many designs those which will best meet his requirements.

The first step toward obtaining equipment which will give satisfactory service is to determine just what is to be expected of it. This involves a thorough analysis of the character of the load and any other conditions of service which have a bearing on the operation of the equipment. A preliminary survey of this nature will do much to prevent costly mistakes or even dissatisfaction with the performance of the equipment after it is installed. In the selection of apparatus, particularly that which is in any way special or intended for use under unusual conditions, it is always advisable to obtain the recommendation of the manufacturer as to the type or design best suited for the purpose in hand. The same thing is true of the installation and operation of the equipment. The manufacturer knows best how his devices should be handled in order to give the results provided for in the design, and it is only the part of wisdom and a matter of fairness all around to take advantage of information he can readily supply.

When Was the Lineshaft Last Tested Out?

HAVE you looked over your lineshafting lately? One man, with many years of experience in investigating the power transmission elements in a large number of industrial plants, recently stated that not one plant in a dozen ever did more than just put a little oil into the hanger and countershaft bearings and loose pulleys once in a while. They did that only because to neglect it meant trouble—burned bearings and hot boxes. But there are other troubles some of which are not so obvious but nevertheless apparent to those who know the signs.

For example, a line of pulleys and shafting which squeak and squeal when starting or stopping shows that something is wrong for mechanical things, like people, seldom "holler unless they're hurt." An investigation probably would show that even with all the belts off a man could hardly turn the lineshaft. Tests would show definitely how much power is used simply to operate the lineshaft—a non-productive power consumption which goes on every minute the motor or other driver is running. The remedy is to align the bearings so that the shaft will turn easily; or better still, to install more efficient bearings which will give an additional and continuous power saving.

Another continuous waste is the gradual slowing up of the system due to adding a heavy friction load and to increasing the number of machines, thus slowing up the lineshaft. When a plant is built the lineshaft speed is fixed at, say, 250 r.p.m. From then on for years each aditional machine has its pulley sizes computed on the basis that the shaft still operates at 250 r.p.m. It may, but chances are that the shaft speed is much less, and every machine dependent upon it for power is operating 5 or 10 or perhaps 25 per cent slower than it should. A speed indicator on the lineshaft will tell the tale and can (and should) be applied when the plant is operating under load. Increases in production of 15 to 20 per cent have been made by bringing lineshaft speeds back to normal.

These two tests are easily applied and so offer no excuse for their neglect. When were they applied last in your shop?

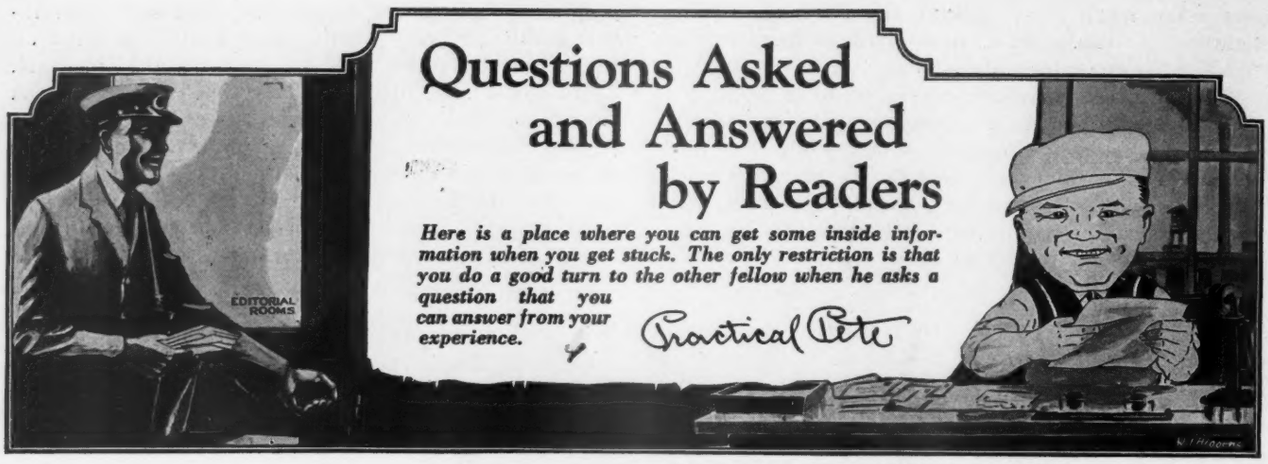
The Economics of Industry— Topic of S. I. E.

IN LINE with the attention which is being directed toward economies in industry, the next semi-annual meeting of the Society of Industrial Engineers will be devoted to this subject. This will be held October 18, 19 and 20 at the Hotel McAlpin, New York City. At this meeting the fundamentals necessary to maintain maximum production with a minimum effort, waste and cost will be treated by a large number of well-known executives and engineers. All meetings will be open to the public with no registration fee.

Some of the subjects covered are as follows: "The Relation of Economics to Industry," by Joseph W. Roe, president of the Society; "The Importance of the Elimination of Waste," by Robert B. Wolf, a member of the Hoover Committee on Waste in Industry; "The Industrial Situation in Russia," by Royal R. Keely, consulting engineer, who has just returned from a two years' work on the reorganization of factories in Russia, and the "Economic Aspect of Production," by Ernest F. DuBrul, general manager of the National Machine Tool Builders' Association, Cincinnati.

A continuation of the discussion on "The Measurement of Management" which was brought up at the Detroit Convention will be carried on at this meeting. Another feature of these meetings will be the discussion on Thursday afternoon by executives and workmen on "How Can We Reduce Production Costs?"

In recognition of the importance of material handling in the "economics of industry," considerable attention will be given to this subject with the last meeting devoted wholly to this. The subject will be discussed under the following heads: (1) Tractors, (2) Trucks, (3) Overhead Conveyors, (4) Gravity Conveyors, (5) Belt Conveyors and (6) Portable Elevators.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Remagnetizing Magnets—Please show a good method for remagnetizing magnets such as used in magnetos and kilowatt-hour meters.
Dixon, Ill. G. L. H.

* * * *

Tracing Connections of Motor Winding—Will someone explain how the connections of a small motor armature can be traced out when an insulating compound is used that completely covers up the leads and connections at the ends of the armature?
Brooklyn, N. Y. I. T.

* * * *

Rates When Renting Motors—On page 348 of the July number, W. M. Price answered a question in regard to charges for maintenance service. I would like to know what his company charges for motor rent or what other companies charge for that service.
Walla Walla, Wash. W. H. H.

* * * *

Changing Single-Phase Motor to Three-Phase—I wish to change a Wagner motor over from single-phase to three-phase. What will be the requirements? Should I short-circuit the commutator? Will there then be enough copper in the rotor? I shall have to change the stator and distribute the winding from four concentrated poles to four or six distributed poles. Should I use the same length and gage of wire to do this or should I figure on more wire and a smaller size? The motor has No. 12 or No. 13 in the fields now.
Ardmore, Okla. R. W. McMURRY.

* * * *

Crane Collector Wires—On a five-ton alternating-current crane, having a bridge or cross travel of about 50 feet, we have experienced considerable trouble with the collector wires sparking at the contacts. Both types of collectors have been tried out: namely, shoes and wheels, and we have been forced to use flexible cables to do away with standard collecting device.

Can readers tell us what the trouble is and how they overcome such difficulties in practice, for we do not feel it should be necessary to resort to the method we have adopted?
New York, N. Y. M. K.

Making Equipotential Connections—In the book by D. H. Braymer on Armature Winding and Motor Repair, page 22, the statement is made, "With lap windings, one ring for every 6 to 12 segments is common practice, but this is scarcely feasible when the number of pairs of field magnet poles is greater than the number of sections of armature winding in parallel, for here the potential pitch may be fairly large and the number of rings becomes prohibitive." In the case of a large generator having 200 or more segments we would have a very large number of rings and they would form a bulky mass. I would like to see an explanation of how to make these equipotential connections for a particular case, showing how the taps are made.
Brooklyn, N. Y. I. T.

Answers Received To Questions Asked

Changing Winding of Induction Motor—What changes should be made in rewinding a three-phase, four-pole, 220-volt, 20-hp. induction motor for operation on a two-phase, 440-volt circuit? The original stator has 48 slots with 48 coils of 14 double turns of No. 14 wire connected two-circuit delta with a throw of 1 and 10. What would be the result if only the throw of the coils is changed to 1 and 12?
Fairfield, Me. M. D. B.

The 20-hp., 220-volt, 3-phase, 4-pole induction motor described may be rewound for operation on a 2-phase, 440-volt circuit as follows: Use 10 turns of two No. 12 wires in parallel per coil. Connect six coils together per phase, per pole. Use same coil of 1 to 10 as before and connect the motor single circuit, 2-phase. The above is based on the 3-phase data given being correct and it being understood that the 3-phase coils had two wires No. 14 in parallel with 14 turns each. If there is enough room in the slots, No. 11 wire be better still than No. 12.
Omaha, Neb. W. E. PAULSEN.

Why Does Verdigris Form Inside Coils?—In using baking varnishes, we have found that not infrequently verdigris forms on the coils of motors in the slots, and also on the lower windings of magnet coils. (1) Does it impair the insulation? (2) Does it lessen the life of a motor or coil? (3) Can it be avoided by using clear varnishes? (4) Is a good grade of black varnish as likely to form verdigris as clear baking varnish?
Springfield, Mass. J. B. T.

The questions by J. B. T. cover the usual manifestations of corrosion caused by or blamed on insulating varnishes, and the better way to answer your several questions would be to give you some information as to the cause of this corrosion or verdigris.

Corrosion is frequently caused by the free acid in the varnish, and consequently, if the insulating varnish has a high percentage of free acid this acid will act on the copper of the coil and develop a malignant type of corrosion which will break down the insulation because it penetrates through the cotton and the varnish film.

Some insulating varnishes, particularly those which are made up principally of linseed oil, will have a high acid number unless, of course, this particular defect is taken care of by the manufacturer. The free acid of a varnish is much more active in the presence of moisture and consequently, if the coils are not thoroughly dried out before the insulating varnish is applied the moisture present in the cotton will emphasize this corrosive effect and the insulation will be damaged.

If, however, the insulating varnish is a low acid number and would not of itself cause corrosion, but the coils have not been thoroughly dried out, the varnish would develop a film over the moist cotton, and in this

way would trap the moisture between the varnish film and the copper and in turn this copper acting on the organic materials in the water would develop a copper salt of a yellowish green color which is not malignant and really has no particular deleterious effect. This is the usual type of corrosion encountered.

Your first question would indicate that your coils were not dried out sufficiently before being dipped, because the corrosion mentioned is in the lower windings of magnet coil. The coil should be heated thoroughly at a temperature in excess of the boiling point of water, and the writer usually suggests 220 F. or 105 C. It is also quite possible that you are using the wrong type of varnish for the deep coils.

(1) Does corrosion impair insulation? This is answered above.

(2) Does it lessen the life of a motor or coil? Obviously. If it is due to the presence of acid or the presence of considerable moisture.

(3) Can it be avoided by using clear varnishes? The color of the varnish is immaterial if the varnish is correctly compounded and is applied in the proper manner.

(4) Is a good grade of black baking varnish as likely to form verdigris as a clear baking varnish? Surely. But you cannot see it in the black.

The writer would suggest that you use a varnish either clear or black with an acid number not exceeding 4; that you dry out your coils perfectly; that for deep coils you use a varnish with a Chinawood oil base; and that your heating and baking temperatures be not less than 100 C. or 212 F., and not in excess of 115 C. or 240 F.

CHARLES A. BARKER.
Managing Engineer,
Dutchess Bleachery, Inc.,
Wappingers Falls, N. Y.

* * * *

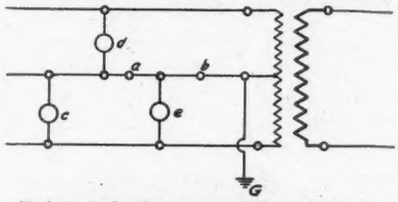
Grounding Distribution Circuits.—Please publish the following to be answered by some of your readers: In our plant we have a 3-wire system for lights, of which the neutral wire is grounded at the transformer. The National Code reads: "If a system is grounded at the transformer it must also be grounded at each distribution box, or at intervals through the plant." We do not happen to have the grounds at intervals in the plant and that is where part of our trouble lies.

I was called to repair some lights in one of our departments with the complaint that some were very bright and others very dim. Upon arriving there I turned out all lights and took each one separately. Circuit No. 1 did not light; circuit No. 2 was burning about 220 volts, or twice normal; circuit No. 3 burned normal. Upon changing circuit No. 2 to normal, circuit No. 1 also burned normal. Can anyone explain this? What good is the ground at the transformer without other grounds at intervals throughout the plant? What harm could result should the permanent ground be removed?

St. Louis, Mo. E. H.

If I had a diagram of the circuits in question I could probably tell more about the trouble, but as it is I can only offer suggestions. I presume that the circuit is about as shown in the accompanying sketch. If a fuse should blow or an open circuit occur at (*b*), the current would flow through lamps (*c*) and (*e*) in parallel and in series with lamp (*d*), with the result that (*d*) would burn bright and (*c*) and (*e*) dim, due to the unequal resistance in series.

The single ground at the transformer has no effect on the lamps, but if ground connections are added on the neutral throughout the plant as at point (*a*) it would make a more substantial neutral and less subject to trouble, as two grounds would bridge a possible open circuit in the



Points to look for trouble mentioned by E. H. on 3-wire circuit.

neutral. The above may not exactly illustrate your case, but it would be wise to check the neutral for bad connections or blown fuses.

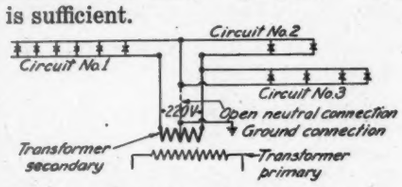
Omaha, Neb. W. E. PAULSEN.

* * * *

In the September issue of INDUSTRIAL ENGINEER, under grounding distribution circuits, E. H. describes a trouble which is *not* caused by the ground connections. The fault in the system is that the neutral connection is open, most likely caused by a burned-out fuse or a loose connection at the fuse or switch.

The accompanying diagram explains just how the "open" neutral will affect a three-wire lighting system. By turning on the circuits in the order named by E. H. the reason for the peculiar action of the lights is readily understood by tracing out the circuits shown. From the description given by E. H. it would appear that the actual load on circuit No. 1 was approximately equal to the combined loads on circuits 2 and 3 at the time he turned them on.

Unless the secondary distribution from the transformer takes care of a load distributed over an extensive area, the one ground connection on the secondary neutral at the transformer and the grounding of the transformer case, if properly made, is sufficient.



Circuit conditions when 3-wire neutral is opened.

In the September issue of the INDUSTRIAL ENGINEER, page 449, the writer gave a table showing the size of wires required for ground connections. The ground connection is not called upon to carry current except when some abnormal condition of the system occurs and its real purpose is to protect the system against excessive voltage. The ground connection performs its function when a ground occurs on one of the "outside" wires of the three-wire system or when transformer insulation breaks down and the high tension current leaks in on the secondary windings.

Washington, D. C. WM. S. JONES.

* * * *

Device for Testing Windings of Small Motors—Will someone be good enough to describe a small testing transformer or similar device such as described on page 45 of the January issue of INDUSTRIAL ENGINEER, that can be used for testing the windings of fractional horsepower motors for short-circuits, grounds, open circuits, and the like?

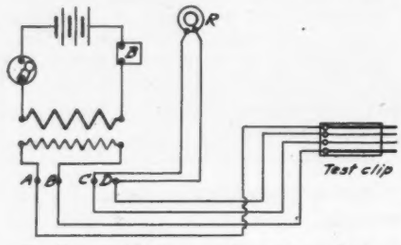
Nanty-Glo, Pa. S. J. S.

S. J. S., who asks in the September issue for details of a small testing transformer, will find the following outfit compact, easily made and efficient.

The parts needed are two or three dry cells, a small buzzer, a single-pole snap switch, one telephone induction coil and a seventy-ohm head receiver.

The battery, switch, buzzer and primary of the coil are all connected in series. A neat outfit can be made by procuring an old wall-type telephone box or any small container that will hold the cells, buzzer and coil. The switch can be mounted on one end and the four terminals for the secondary on the other end. The leads (*a*) and (*b*) go to two of the binding posts and receiver wires (*c*) and (*d*) to the other two.

When testing for grounds, connect (*b*) and (*c*) together. Leads are then taken from (*a*) and (*d*). Energize the primary circuit and apply leads (*a*) and (*d*) to the windings to be tested. If a dead ground is present a loud hum will be heard in the receiver. Partial grounds will give a sound somewhat less in intensity than that produced by shorting



Testing outfit for small motor windings.

the test leads together. A slight clicking noise caused by the condenser action of the winding under test will always be heard, but you can easily recognize it.

When testing for shorts, opens, etc., a good contact clip can be made from a piece of ⅜-in. fiber and a few thin brass strips, as shown in the sketch. Connect as shown by the dotted lines. The two center contacts should be adjusted to bridge two adjacent segments on the commutator and the outer clips to rest about six segments apart. A normal coil will give a definite buzz in the receiver. Opens are indicated by a loud buzz and shorts by an absolute silence. Partial shorts will be indicated by a noise in proportion to the resistance of the defect.

After a few trials you can test field coils and small a. c. windings with results as accurate as those obtained with d. c. armatures.

This set is extremely sensitive, the intensity of the sound varying with the slightest alteration in the resistance of the circuit being tested. It can be used for many purposes besides those mentioned here.

Chicago, Ill. D. F. O'DONNELL.

* * * *

Heating of Low Voltage Release Coil on Compensator.—We are having trouble with heating of the low-voltage release on a 10-hp. compensator used with a 220-volt a. c. motor. The coil is 3 in. long, 3 in. in diameter with the diameter of core tube 1⅛ in. It has approximately 3,000 turns of No. 27 silk-covered enameled magnet wire.

The core is made from iron laminations taken from an old transformer, the dimensions of which are as follows: Length 4¾ in.; diameter, 15/16 in., approximately.

The inside diameter of core tube is 1 in. The coil used gets hot after about one hour's operation. We would appreciate it if someone will help us by giving a solution of this trouble.

Walsenburg, Colo. E. P. McC.

The writer was interested in an answer by Wm. Harper on heating of low voltage release coil on page 444 of the September issue, but I do not agree with him on all points. For instance, the magnetic torque or pull is determined by the ampere turns of the coil, and this in turn by the size and length of the winding. Consequently, if there is too much wire, there would be too much resistance. This would, of course, cut down the current and by so doing decrease the heating rather than increase it. If one-third of the winding was cut out, the resistance would be lessened and more current would flow and increased heating would result. It makes no difference in the writer's opinion whether it is a 1, 2 or 3-phase compensator, as the no-voltage coil is connected across only one phase and the operation would be the same in either case.

We have several compensators with no-voltage release coils and find that all such coils run warm, as the energy consumed is dissipated in heat but as long as they do not heat above 40 or 50 degrees we consider them safe, and so far have had no roasted coils. Of course if the coil in question roasts it is possible that there is a short circuit in the winding of the coil. On the other hand, if it does not roast a temperature test would soon determine whether or not the coil is overheating. Certain allowance must be made for heating in such cases. If the coil is not roasted the writer would suggest rewinding with a smaller size wire, or increasing the amount already on.

Ansonia, Conn. WILLIAM T. ESTLICK.

* * * *

Tool Box for Electrician's Equipment.—Several designs of tool boxes are made suitable for tools used by a machinist. I would like to ask fellow electricians to offer for publication in INDUSTRIAL ENGINEER the construction and design for any special tool box which they have found convenient for carrying around the shop the tools that are commonly used and purchased by them personally. I have in mind a small size tool case about 2½ ft. long by 24 in. wide by 24 in. deep with suitable trays and compartments.

Chicago, Ill. J. M. B.

With reference to J. M. B.'s request in the August issue of INDUSTRIAL ENGINEER for designs of tool boxes, I am inclosing a blue print of one type of box for personal tools. The size mentioned is not convenient for carrying tools around the shop, but is a box for storage of tools.

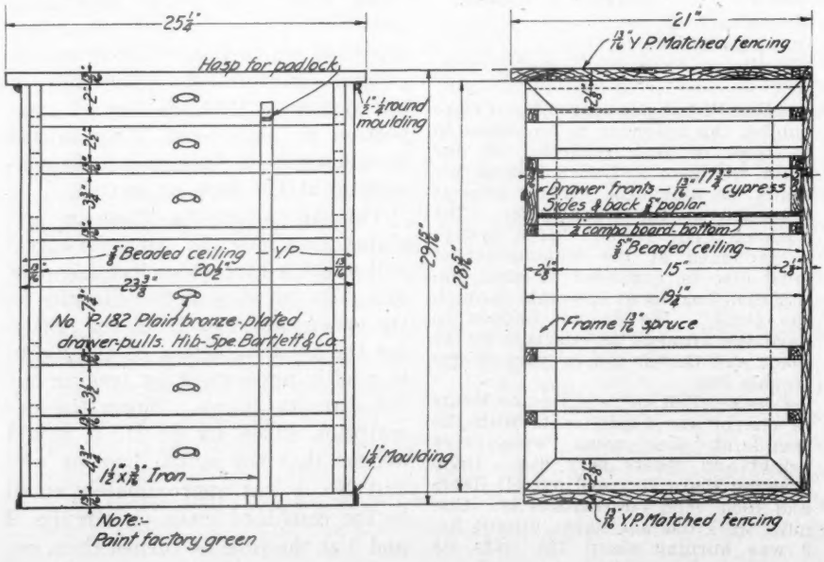
The following material is required to make one box:

Beaded ceiling, ⅝ in.	15 bd. ft.
Matched pine fencing, 13/16 in.	8 bd. ft.
Poplar, ⅝ in.	9 sq. ft.
Spruce, ⅞ in.	4 sq. ft.
Cypress, ⅞ in.	8 sq. ft.
Finishing nails, 2 in.	½ lb.
Drawer pulls, No. P-182 (Hibbard, Spencer, Bartlett & Co.)	6
Factory green paint	½ pt.

For carrying small parts and tools we ordinarily use a wooden tray 8 in. wide, 6 in. deep and 18 in. long, divided into two or three compartments and with a strap handle for carrying. Provision could easily be made for such a tray in the top of the box described here.

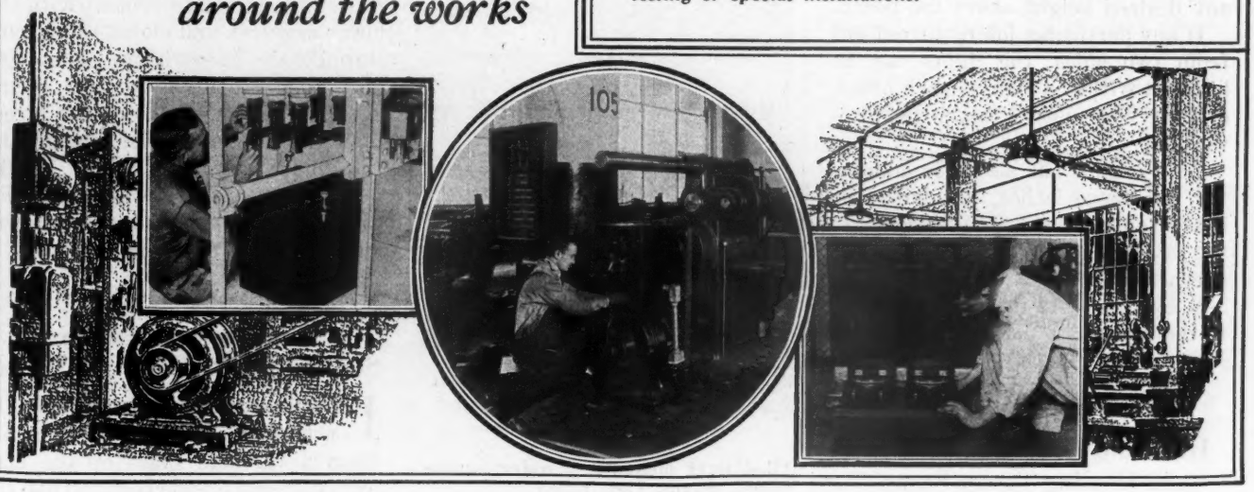
La Salle, Ill. L. B. C.

Details for construction of electrician's tool box.



SERVICE
around the works

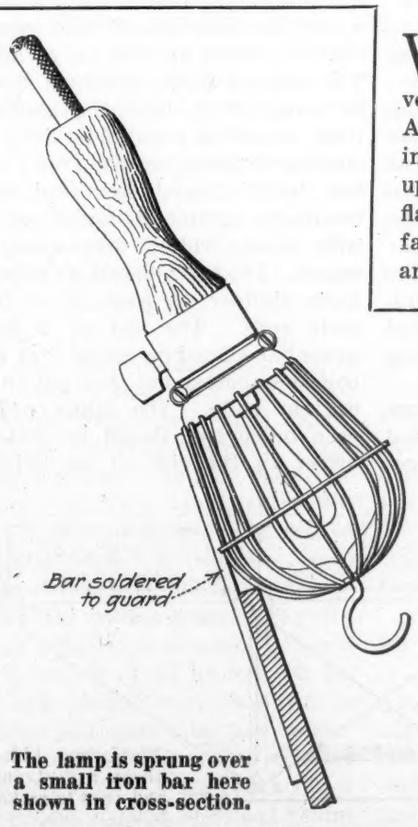
For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Bar on Portable Lamp Guard Holds Lamp in Place

REPAIR work around motors when lighting conditions are poor is always difficult because the portable lamp can seldom be fixed in the right place and often both hands are occupied. However, by soldering a small bar or piece of wire to the metal guard, as shown in the illustration, this portable lamp can be sprung over a rod or other support so that the rays will be directed toward the work. The lamp will stay in position, due to the slight tension of the soldered wire against the support. JOHN W. PEARSON.

Chicago, Ill.

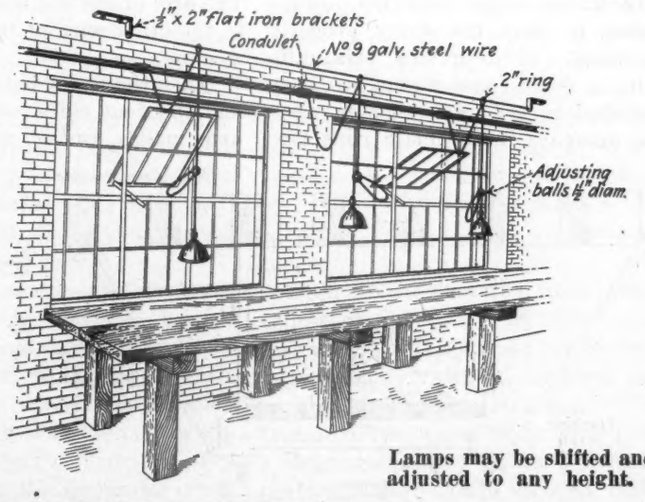


The lamp is sprung over a small iron bar here shown in cross-section.

An Easy Way of Providing Adjustable Lights for Benches and Lathes

WE HAVE installed in our repair shops and on our lathes a very satisfactory system of lighting. As will be seen from the accompanying sketch for bench lighting, we put up two brackets of ½-in. by 2-in. flat iron bent at right angles and fastened to the ceiling by lag screws and expansion shields about 18 in. from the wall. Between the brackets we stretched a No. 9 galvanized wire as tightly as possible, about 1 ft. from the ceiling. The conduit carrying the lighting circuits was located on the wall back of the bench, about 2 ft. below the level of the steel wire. In this case two "J" condulets and one "K" were used with cord receptacles "No. CC332." We used No. 16 packinghouse cord between the receptacles and ⅜-in. cap brass sockets with 10-in. metal reflectors.

For each light a round iron ring 2 in. in diameter was used and placed around the steel wire so as to slide towards one or the other end of the bench, as desired. The ring was taped over on one side and the packinghouse cord taped to it, about 5 ft. being left between the receptacles



Lamps may be shifted and adjusted to any height.

and the ring so the ring and cord have a side adjustment of at least 8 ft. To adjust for height we placed a wood adjusting ball on the cord. This allows the light to be placed at any desired height above the bench.

If any particular job requires light from two sides, the lights can be brought within a foot of each other, or otherwise placed to the best advantage.

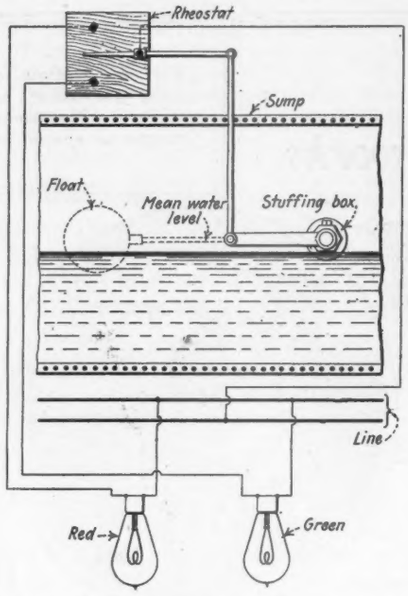
This scheme has also been adopted for use above lathes and drills and has given complete satisfaction. In the latter case the circuits were run overhead on knob insulators with 2-in. by 4-in. by 12-in. boards clamped to the trusses. J. H. GALLANT.

Bel'eville, Ontario, Canada.

Colored Light Signal Shows High and Low Stage of Water in Cooling-Tower Sump

AN ELECTRICAL device for indicating either high or low water in the sump beneath a cooling tower is shown diagrammatically in the accompanying sketch. The tower is used in connection with the refrigerating plant of a large dairy. The water for condensing purposes is taken, through a meter, from the city mains; hence the advisability of precautions for conservation.

A good deal of water is used in the dairy for washing and cleaning and is drawn from the sump of the cooling tower. This sump thus serves as a house tank, besides delivering cooling water to the ammonia condenser. The make-up water is delivered under city pressure from the street main to the sump, through a float-controlled valve. Owing to the heavy demand for water in a neighboring meat-packing plant at certain hours of the day, the pressure in the main does not always suffice to keep the dairy properly supplied. To overcome this difficulty a centrifugal pump has been installed to act as a booster when the pressure in the main runs low.



Red light means low water—green light means high water.

There are also periods when very little water is drawn from the sump for cleaning purposes. At such times the sump fills up through the float-controlled valve in the supply pipe and the constant return of water to the cooling tower by the condenser circulating pump will cause the sump to overflow. Thus there are times when the tendency is toward a scarcity of water, and still other times when the tendency is toward an overabundance and waste of water. The signaling device gives notice of these conditions.

Two lamps—one red and the other green—are located in a conspicuous place in the engine room. The red lamp is connected between one wire of the distributing system and the upper segment of the rheostat. The green lamp is connected between the same wire and the lower segment. The arm of the rheostat is connected to the other wire of the distributing system.

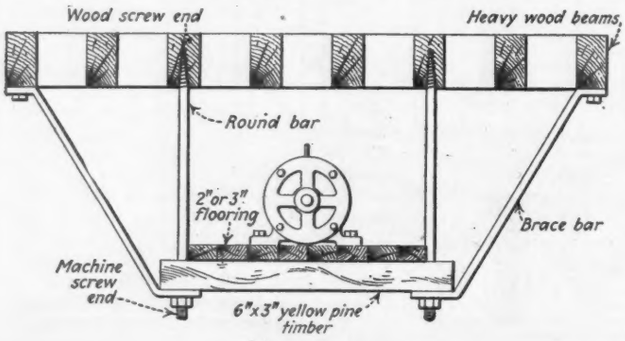
When the water is low in the sump, and the float rides low, the rheostat arm makes contact with the upper segment and closes the circuit through the red lamp. The engineer then starts the booster pump. But when the float rides high, due to the water standing at overflow stage, the rheostat arm makes contact with the lower segment and closes the circuit through the green lamp. The engineer then stops the booster pump, shuts off the supply from the street main to the feed-water heater and the house hot-water tank in the boiler room and opens a valve which connects them with the cooling-tower sump. A. J. DIXON.

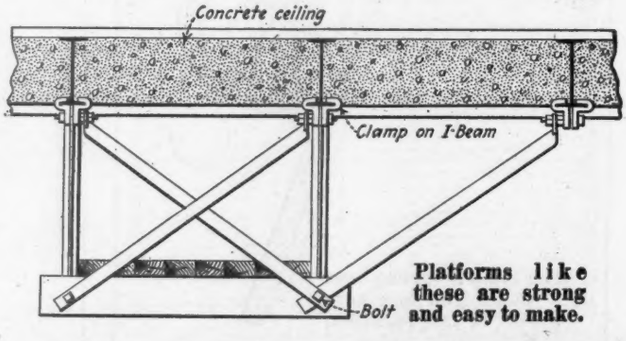
St. Louis, Mo.

Simple Platforms for Suspending Motors Near Ceiling

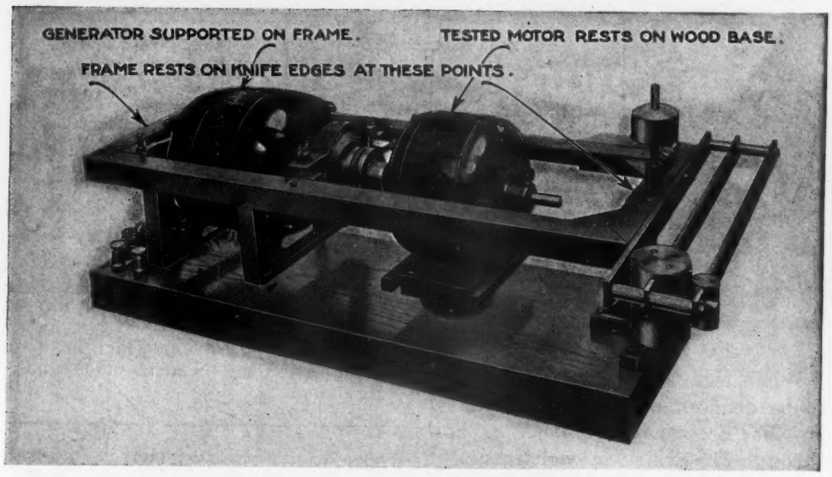
IT IS sometimes convenient or necessary to remove a motor from a valuable space on the floor and suspend it overhead. This can be done safely in almost any building that is suitably erected for machinery, as the timbers are large enough to carry any reasonable weight.

In the case of a frame building, two heavy timbers in the ceiling should be selected and four ¾-in. bolts made with a wood screw on one end and a machine thread on the other end, screwed into them. The length will vary according to the size of the motor. For a 5-hp. motor the bolts should be threaded into the beams about 8 in. or more. The distance to the platform should be about 30 in. and the platform itself should be about 8 in. deep, including the floor boards. Iron plates 3 in. by 3 in. should be placed under the platform timbers, which are set with their widest dimension upwards. The bolts should go through these timbers at least 4 in. from their ends. The end of a ¾-in. brace bar should be placed over each bolt and another nut then put on the upright bolts. The upper end of each brace bar should be fastened either to the side of an adjacent





Platforms like these are strong and easy to make.



The power of a small motor can be measured accurately with this balance.

ceiling timber or to its under edge by bolts or long lag screws. The timbers forming the base of the platform should be at least 6 in. by 3 in. of good quality yellow pine, and form only two sides of the platform, while the floor boards may be of 2-in. solid planking fastened in the other direction preferably with either bolts or lag screws, not merely with nails.

Before the motor is installed, see that the platform is steady and exactly level and that all bolts and nuts are tight. To elevate the motor is practically the easiest part of the job. Into a beam over one edge of the platform fasten a screw-eye and to it attach a rope tackle, the other end of which is hooked to a chain or rope carried around the base of the motor. Place a couple of strong 2-in. planks slantingly against the front edge of the platform and nail at their upper ends to prevent them slipping upward with the motion of the motor. Two men can probably draw the motor up quite easily and put it in place on the platform in a few minutes. It should then be firmly bolted to the floor boards.

If the beams in the ceiling are of steel, such as are found in fireproof buildings, then special steel clamps should be bolted to the lower flange of the beam and the long bolts held securely in place by clamping the head of the bolt in a recess cast in the beam clamp. In this case braces may be bolted to the four clamps holding the platform up, or to other clamps attached to adjacent I-beams.

For motors of 25 hp. in size the long bolts should be at least 1 in. in diameter and extra ones may be necessary midway. The base timbers for heavy motors should be about 4 in. by 8 in. of good, seasoned yellow pine, and the floor boards should be 3 in. or 4 in. thick, preferably with an under support midway to prevent the floor from springing.

The belt from the motor may be carried straight ahead to a countershaft or downward to a driven shaft below. The switch is generally placed directly below the motor so as to be handy and always in sight.

New Britain, Conn. H. S. RICH.

A Device for Determining the Power of Small Motors

A DYNAMOMETER which measures very accurately the brake horsepower of fractional-size motors has been made at the Armour Institute of Technology. This machine does away with errors which are likely to occur in the common method, which takes total input and then subtracts losses. The trouble with this method is that the losses in very small machines are difficult to determine accurately.

The dynamometer consists essentially of a frame pivoted at each end on knife edges. On the frame is mounted a generator whose axis coincides with the axis of the frame. The tested motor is set on the stationary base and drives the generator through a direct coupling. This tends to tilt the frame. A sliding weight on the frame is adjusted to restore a balance. The position of the weight indicates the power which the motor is exerting.

This dynamometer was designed for testing motors up to ¼ hp. It is a cradle dynamometer in that the deflected element is carried on knife edges, and an electric absorption dynamometer in that the load is absorbed by an electric generator. The frame carrying the generator rests on knife edges of hardened steel placed in sockets on pillow blocks, the knife edges being in the axis of rotation of the generator. The pillow blocks rest on the base on which the motor to be tested is mounted. The motor is clamped to an iron pedestal which can be raised or lowered by means of a thread cut on the supporting post and working in a plate fastened to the base. The motor to be tested is coupled directly to the generator by means of fingered flanges meshing in openings cut in a leather disc. This coupling obviates the necessity of careful alignment of the shafts. The speed is determined by means of a frequency meter operated by direct current supplied from an outside source, but interrupted by a make-and-break attachment on the generator shaft. This makes the speed determination positive and introduces no error due to unmeasured tachometer losses. The accuracy of reading the speed is 0.5 per cent. The generator field is also excited from an outside source, giving very sensitive control. The outside connections of the generator are made through stranded conductors of great flexibility.

The generator is a ½-hp., 110-volt, 1750 r.p.m. machine. The armature is carried on ball bearings which reduce the friction loss (hence the minimum load obtainable) to the lowest possible limit. Under test, this lower load limit was found to be 0.015 hp. at 1800 r.p.m.

The scale arm is a double-beam type, the movement of the small weight the full length of one beam being equivalent to one division movement of the large weight on the other. The scale beams are placed across the end of the supporting frame and each is marked with a double scale. The readings of one multiplied by the speed give the horsepower; the reading of the other multiplied by the value of the corresponding weight gives inch-pounds torque.

Each division on the small beam represents 0.0009 hp. at 1800 r.p.m. and a balance is obtained not by final adjustment of weight position, but by generator field variation. The frame carries a pointer moving past a scale attached to the base, so that perfect balance can be secured, mak-

ing the scale reading very sensitive. The dynamometer can be used either as a generator or a motor. In the latter case the no-load deflection must be deducted from the scale readings to obtain the input to the generator under test.

Sometimes it is desirable to measure loads much in excess of the rating of the dynamometer generator, but applied for a short time only, as in breakdown tests on alternating-current motors. To meet this need, a pulley is placed on the shaft of the generator and a special brake shoe is attached to the frame. The pulley can be water cooled if desired. The brake lining is that used on auto brake shoes. This brake is spring steel and when not in use clears the pulley entirely.

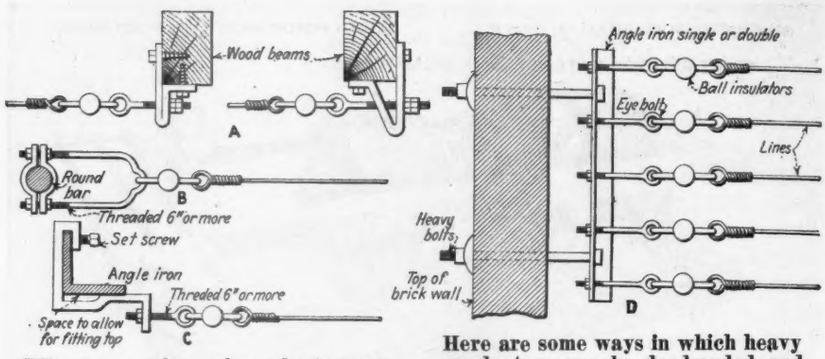
The center of gravity of the frame is adjusted approximately to the knife edges by means of a lock-nutted counterweight moving on a threaded post. The balance on the knife edges is adjusted by a self-locking weight moving on a similar post at right angles to the former. The total weight of the dynamometer is about 100 pounds. JOHN E. SNOW.

Associate Professor Electrical Engineering, Armour Institute of Technology, Chicago, Ill.

Easily-Made Substitutes for Turnbuckles to Tighten Wires

WITH no turnbuckles at hand, taking up the slack in a heavy line is often a problem. Instead of ordering special fittings for this purpose many useful "take-ups" can be made. If a line is to be dead-ended on a wood beam for example a piece of ½-in. iron 1½ in. wide can be bent up and then drilled for two lag screws and one bolt, as shown at *A*. Of course, ball insulators should be used to break the circuit and to these should be attached eye-bolts with about 6 in. of thread with which to take up the slack in the line. Where a ball insulator is close to a round bar it may be fastened and the line drawn up with a U-shaped bolt threaded on both ends for about 6 in. and passing through a strap or two, as at *B*, in the accompanying sketch.

Where a line is to be ended at an angle-iron beam a strap ½ in. thick and 2 in. wide may be bent to slip over the upper edge of the beam and if necessary be held with a set screw. Drawing *C* shows this method.



Here are some ways in which heavy conductors can be dead-ended and tightened.

When a number of conductors are to be dead-ended at a brick wall it is not necessary to pass a bolt through the wall for each insulator to be attached. Take one or two lengths of angle iron ⅜ in. thick and long enough to space the conductors 12 in. apart. If th· strain is considerable, use the iron double; if not, single will be sufficient. Drill holes for the insulator eye-bolts and other holes for two ¾-in. bolts passing through the wall. These latter bolts should be long enough to keep the bars about 7 or 8 in. from the wall, to allow for taking up the line slack. No matter what kind of a dead-end arrangement is used, there should be some means provided to take up the slack, for almost any conductor will sag after a while. H. S. RICH.

New Britain, Conn.

Training Workmen in the Proper Operation of Enclosed Safety Switches

THE enclosed externally operated switch is far in advance of the open switch as far as safety is concerned, but even then some degree of intelligence is required. Several years' investigation of accidental electrical burns occurring at motor switches shows that enclosed switches will eliminate about 75 per cent of the accidents usually occurring with open switches. The remaining 25 per cent of accidents can be decreased only by education and rigid inspection of all enclosed motor switch boxes. By education is meant the posting of bulletins and the personal explanation of the cause of flashes or shorts in switch boxes.

The usual cause of the trouble is the workman who gingerly throws in or pulls out a switch or tries to "inch" or "jog" a motor along where the motor has no compensator. In the absence of a reliable quick-make-and-break attachment on the switch, the workman must be strongly impressed with the fact that the switch must be thrown in or out with a quick, firm motion or else an arc will form which may spread to the adjacent switch blade, the hot vapors affording a path for a short circuit. This may blow the door off the switch box or else force the flame out around the edge of the box and burn the face and arms of the operator.

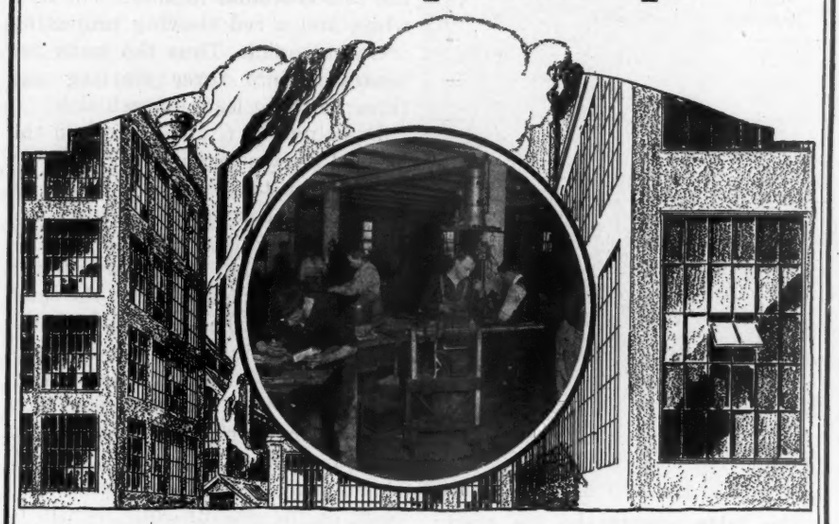
Another danger exists with inexperienced operators who do not observe whether or not the starting compensator is in the "off" position before throwing in the line switch. Many serious accidents have occurred in this manner where a line switch for a large motor has been closed with the compensator in the "on" position. It should also be pointed out to the workman that if there is a compensator in the line, the line switch should never be opened while the motor is running but the motor should first be disconnected by tripping out the compensator.

In order to secure the maximum protection where unavoidable flashes occur, the door of the enclosed switch should be locked or suitably secured so that it cannot be opened without tools. This is necessary because any ordinary latch will spring open or the door will be left open by careless individuals. Should the door be blown open the burn received by the operator may be much greater as the flames then shoot out with explosive violence. A rigid system of inspection of boxes should be made at intervals to see that the locks and latches are maintained in operating condition at all times.

Much credit is due to the manufacturers of switches for improvements in construction, but the prevention of many accidents depends upon the education and vigilance of the operator. J. E. HOUSLEY.

Aluminum Company of America, Kansas City, Mo.

In the Repair Shop



This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welcome.

How to Locate Reversed Field Coils with Alternating Current

IT IS often necessary to test field and other coils for polarity where direct current is not available, and for this purpose a test set has been constructed by the writer.

On a small board were mounted a few low-voltage lamps with a suitable arrangement for using the lamp wanted. A 6-volt, a 24-volt, and a 50-volt lamp are sufficient. A couple of 110-volt watthour-meter shunt coils were each mounted on a small piece of laminated iron and leads provided for connecting to the terminals of the coils. These two coils were connected in series with one of the lamps in such a way that the induced voltage within them would be added when an alternating flux is passed through their cores in the same direction.

In testing the field of a machine to ascertain whether the connections are right, one of the test coils is placed on one pole face and the other placed on an adjacent pole face while an alternating current is sent through the field coils. The 50-volt lamp should be used first and if this does not light, then the 24-volt and finally the 6-volt lamp may be tried. The lamp will not light if the polarity of the two poles under test is opposite. Should one of the coils be moved to the next pole, leaving a pole between, the lamp should light if the connections are right on that part of the field. One of the test coils can, therefore, be held on one pole face while the other is moved around the field structure, from pole to pole, and the connections quickly and accurately determined.

This arrangement may also be used for locating reversed coils in an armature. C. M. HATHAWAY.

Colorado Springs, Colo.

Simple Diagram to Show Motor Connections

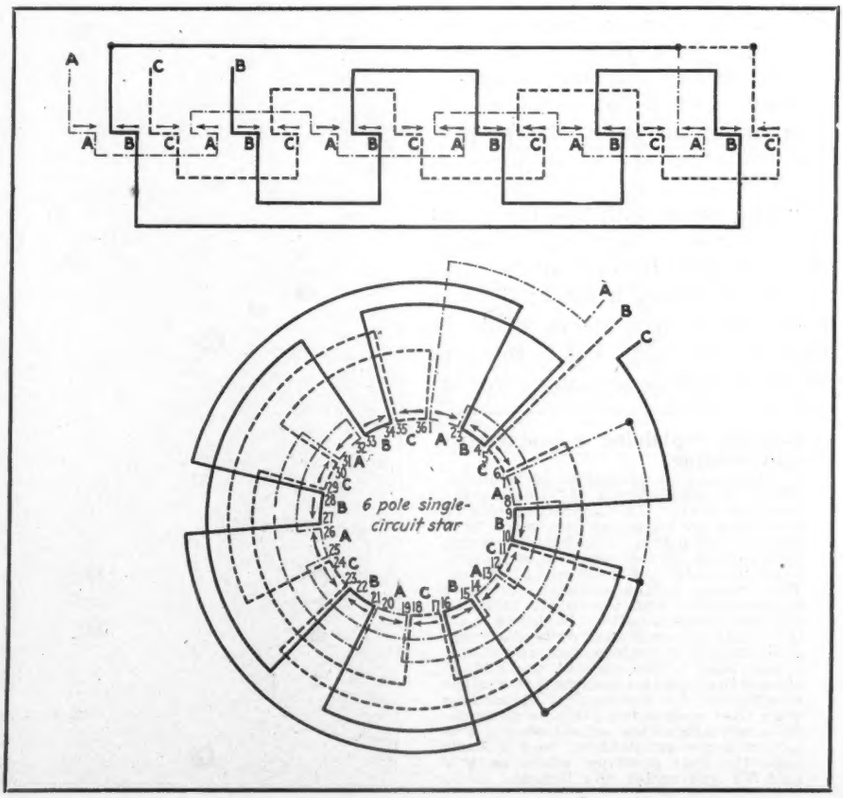
A VERY simple method of showing the connection of an induction motor is shown in the accompanying drawing. The different kinds of lines shown in this drawing represent the markings of pencils of different colors. Blue, red and black pencils are used for the three-phase motor shown. Only two colors, of course, are required for a two-phase diagram.

The round figure at the bottom shows the end-connecting leads for each group of coils, each color representing one phase. Above is the same winding laid out in a flat form which will help to make plain the round figure. Both ends of each group are numbered. On the same sheet with the diagrams are placed

A connection diagram like this is easy to understand.

This is a three-phase, six-pole motor, connected series-star. The different kinds of lines represent different colors, blue for phase *A*, red for phase *B* and black for phase *C*. On the same sheet with the drawings are placed the following directions telling where to connect the jumpers between groups and the motor leads.

Phase *A*—Connect 2 to 13, 14 to 25, 26 to 32, 31 to 20, 19 to 8.
Phase *B*—Connect 6 to 17, 18 to 29, 30 to 36, 35 to 24, 23 to 12.
Phase *C*—Connect 10 to 21, 22 to 33, 34 to 4, 3 to 28, 27 to 16.
Connect motor leads to 1, 5 and 9.
Connect star to 7, 11 and 15.



the numbers shown in print underneath the caption. These numbers tell which groups of coils to connect together and which to connect to the the motor leads. R. McDONALD.

Chief Electrician,
Mohawk Carpet Mills, Inc.,
Amsterdam, N. Y.

Special Hand Winding Saves Time in Rewinding Small Armatures

A HAND winding for small armatures which will save time is possible if the number of slots is not divisible by four and the coils are wound full pitch. It must not be attempted with a chorded pitch. This is a "progressive split" winding which was used in rewinding a 1-hp. direct-current armature with 22 slots and 66 bars and a pitch of 1 and 12 (full pitch). In winding, eleven coils were wound on, each slot being filled as the winding progressed. Six wires in hand were used while in an ordinary loop winding three wires would be used and twenty-two coils wound.

Drawing *A* shows the complete winding and the accompanying table gives the sequence of putting on the coils. A circle with a cross is used to indicate the start of a coil, and the small black circles enclose figures which indicate the coil numbers. As stated above, this type of winding fills the slots, starting with the first coil in. In winding, therefore, the leads must be marked so that each slot will contain one start or bottom lead and one finishing or top lead.

In an ordinary split winding having two, three and so on times as many bars as slots the armature would be wound with two, three, and so on wires in hand and a white sleeve would be put over all the wires in hand to denote a finish; likewise a red or a black sleeve would be used for the start. But in this type of winding twice as many wires are used. For instance in the present winding there are six wires in hand. Then to distinguish a top coil from a bottom, the wires are divided into two sections of three wires per section before starting to wind. One section would first have a white sleeve put on over the three wires, then a red sleeve. The other section would have the sleeving reversed; *i. e.*, a red first, and a white last (see *E*). By following this plan, when the coil is wound in there will be a white and a red sleeving projecting from each slot. Thus the leads are separated into three starting and three finishing leads in each slot.

Drawings *B*, *C* and *D* explain the method of winding in the coils. At *B* the first two coils are shown in place. Coil 1 is wound in slots 1 and 12, and coil 2 is started in slot 14, skipping one slot. The start of each succeeding coil is located in the same manner. Call the slot in which the last coil is finished "No. 1" and count over to "No. 3" in a clockwise direction. This is where the term "progressive" originates. At *C*, four coils are shown in place, and at *D* six coils are shown, also the starting point of the seventh coil. It will be noticed at any time during the winding that between the last two coils put in, there will be one slot intervening on each end of the coils.

Drawings *F* and *G* will explain how the leads are connected to the commutator and why this type of winding must be full pitch. In *F* the coil is shown in the neutral region with the leads brought over to commutator bars just on each side of

Sequence of Windings

Coil Number	Slot Number	
	Start	Finish
1	1	12
2	14	3
3	5	16
4	18	7
5	9	20
6	22	11
7	13	2
8	4	15
9	17	6
10	8	19
11	21	10

This table accompanies the chart at the bottom of the page.

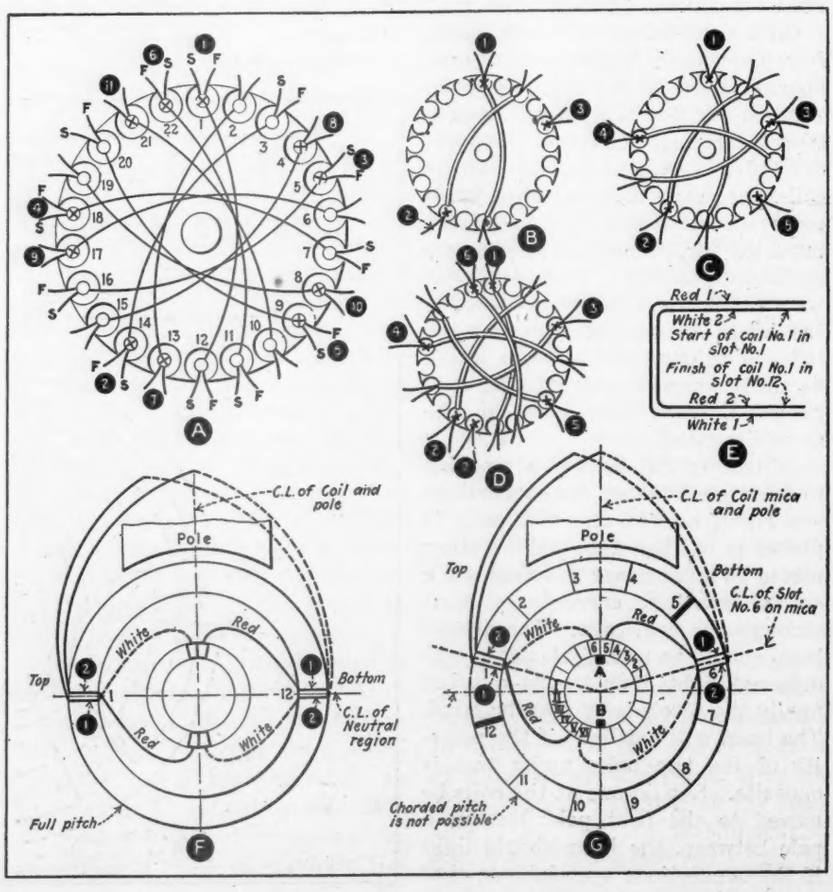


Diagram explaining a progressive split winding.
A. This shows sequence of winding which is also shown in the accompanying table. The armature has 22 slots and 66 bars and the pitch is 1 and 12, full pitch. The figures in the small black circles are the coil numbers in order of putting in place. The crosses indicate where coils are started. *B*, *C* and *D* explain steps in putting on the coils. *E* shows how the leads are marked with sleeving. Red denotes a bottom lead and white a top lead. The correct method of connecting up the commutator is indicated in *F*. From *G* it is clearly seen that a chorded pitch is not possible with this type of winding. The heavy lines at slots 12 and 5 indicate the coil position when bars V and VI are under the brush.

the center line of the coil. The leads of coil 1 are laid down across the top of the commutator while those of coil 2 are laid down under the commutator. The two leads from one coil are separated by the center line of the poles which indicates that the coils and lead throw are correct.

In *G* the coil pitch is chorded, 1 and 6, on a twelve-slot armature. With the coil in the proper commutating position as shown, the bottom lead of coil 1 is put in bar 5 and the top leads are brought over to bar 6. This makes conditions correct for proper commutation. Now when all the bottom leads have been put down in this way, half the coils will have the correct lead pitch and the other half will be considerably out as coil 2 shows. The leads of coil 2 will be two bars out of true and when bars V and VI are under brush *B*, the coil will have assumed the position indicated by the heavy slot lines 5 and 12. Thus it is readily seen that to wind correctly, the coil pitch must be full.

Detroit, Mich. A. C. ROE.

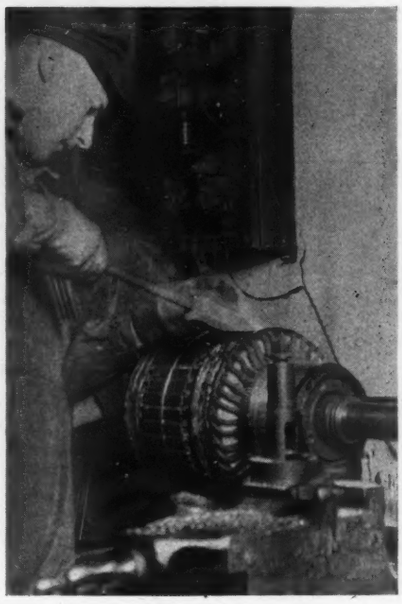


Fig. 1—A wedge-shape iron is preferable for soldering band wire on a commutator.

The fiber strip under the band wire protects the coils underneath from both the solder and the effects of the heat. As a rule, four or more copper strips about one-half inch wide and one-half inch longer than the width of the band are placed between the fiber and the band wire. When the band wire is all in place, the ends of the strips are bent up over the top of the band and soldered fast to it on the top. These clips hold the band firmly in place during the remainder of the soldering operation. It is easier to get a smooth finish to a band soldering job with a wedge-shaped iron than with a pointed one.

Banding Armatures and Turning Commutators

THE final operations, except for painting, in the repair of an armature, are usually banding and turning the commutator. For the usual run of armatures for steel mill motors of 10 to 100 hp. rating, No. 16 or No. 17 steel banding wire is used. The wire is bought in reels and comes already tinned. The band is wound on, using power on the lathe head for turning the armature. The tension on the banding wire is regulated by a clamp on the tool post through with the wire feeds. When the band is sufficiently wide (from 1 to 2 inches for the size of the motor mentioned) the lathe is stopped and while the tension is still on the wire the band is soldered enough to hold. The wire is then cut off and the soldering is finished. A medium sized wedge-shape iron is most suitable for this purpose.

Turning commutators is an art. The shape of the tool has everything to do with the finish of the job. For working in copper a different rake and cutting angle are used than with steel. A tool with a bend to the left is the best, for it enables close work next to the radials. The illustration shows a tool holder and a small piece of tool steel in use, but a large, solid tool clamped directly in the tool rest gives less trouble from vibration. A pointed tool and a slow cross-feed are used. Two cuts are usually taken, a medium cut and a light finishing cut. The final finish may be given by using sandpaper or a fine file while the armature is running in the lathe.

Indiana Harbor, Ind. A. J. W.

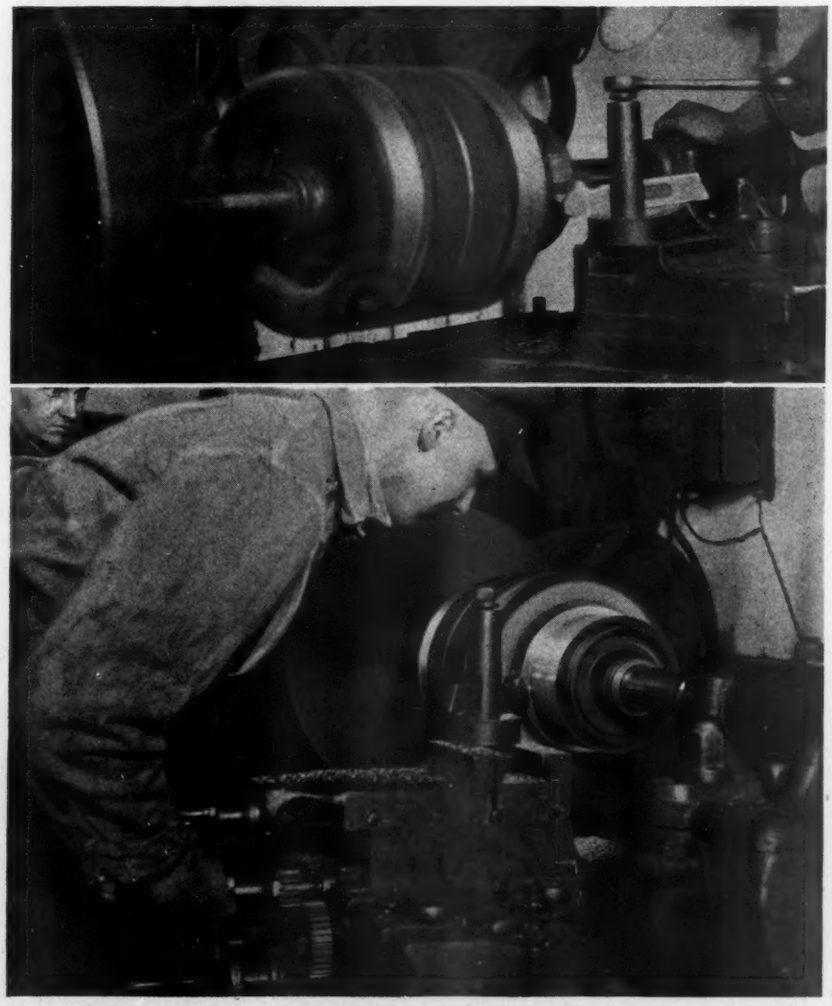


Fig. 2—Turning the commutator after rewinding an armature.

The upper illustration shows the shape of tool point used and the manner in which the tool is mounted in the tool post. Very fine cuts must be made with a pointed tool to get a good finish on the commutator. It is necessary to watch the job closely as the cut approaches the inside end, in order not to go in too deeply in the connection lugs. This is particularly true where long lugs are used. The lower illustration shows the setting of the tool with respect to the relative positions of shaft center and cutting point, the tool point being slightly below the shaft center.

Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

Building Permanent Rollways on a Four-Wheeled Truck to Eliminate Material Handling Accidents

A COMMON method of handling heavy, round objects, such as barrels or rolls of paper, is by a four-wheeled truck. Here, however, some means must be found for loading. Lifting is too heavy work and requires too many men. Skids or rollways as ordinarily used are likely to slip off, and so are dangerous, or are never to be found when wanted.

Both of these drawbacks to the use of rollways are overcome in the truck used at the Marathon Paper Mills Company, Rothschild, Wis., as shown in the accompanying illustration.

Here the rollways are made of iron bars which slide between two angle-irons closed at the end. The ends of the bars are hooked so that they do not pull clear out. When the truck is loaded or unloaded the bars are slipped back into the angle-iron carriers out of the way. Since these bars do not fit tight the ends may be raised to a point higher than the level of the truck as when loading on or unloading from a higher platform, wagon or motor truck. Also as they are always on hand when wanted no time is lost in hunting around and perhaps using a makeshift which might not be strong enough and cause an accident.

Adding this permanent rollway to the four-wheeled trucks practically eliminated the numerous accidents which formerly had been a common occurrence in handling the heavy rolls of paper. It also prevented damage to the rolls from falling when the rollways slipped, which had amounted to a considerable item.

Doubling the Capacity of a Mineral Water Bottling Plant by Conveyor System

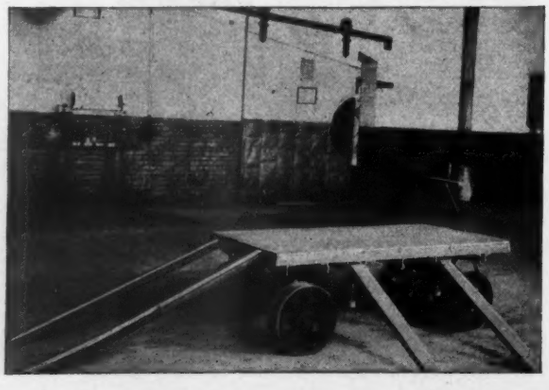
WHEN a plant is continually pushed to maintain sufficient output to keep up with the demand it has, in general, two possibilities: It can increase its space, force and equipment, or it can devise better methods of doing the work which will increase the capacity with the same or less space, force and equipment. It is usually possible, and generally much more economical, to devise better methods. In particular better material handling methods often offer opportunities for more efficient operation.

Conveyors afford one method of handling material at low cost when the material passes over a fixed path, as in passing from one operation or machine to the next. Such were the conditions at the mineral water bottling plant of Hinckley and Schmitt, Chicago, Ill., where, during the summer, the plant was pushed almost night and day to keep up with the demand for water. As a result there were installed a new mechanical bottle filler to which the bottles are fed and taken away by a belt conveyor and a roller conveying system which handles the cases, and these devices have practically doubled the capacity of the plant.

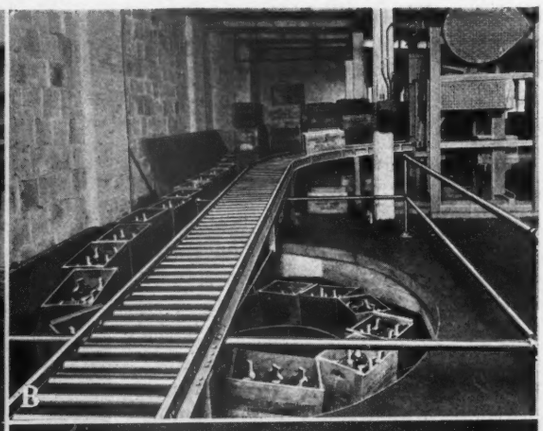
The mineral water business is divided into two general divisions: Cases of half-gallon or gallon bottles of various brands for home, club or hotel consumption and 5-gal. bottles for water cooler service in Chicago office buildings. Each is handled on separate conveyor systems on different floors.

The empty half-gallon and gallon bottles in their cases are unloaded from the wagons or trucks onto lift-truck platforms or four-wheeled trucks as received on the first floor. These are wheeled to the automatic elevator shown in *E*. A man places the cases on the movable platforms which are connected to a continuous chain belt, as shown, and lift the cases to the fourth floor. Illustration *D* shows one case on the way up. It is carried over the top and comes down on some fingers which lift it from the elevator and automatically discharge it onto a roller conveyor. In this way a man is required only for loading the lift.

From this lift, which is also shown in the background in *B*, the case of empty bottles goes on the roller conveyor, here shown empty, to the bottle washing machine which



Building a permanent rollway on a four-wheeled truck. This rollway is always on hand for handling heavy rolls of paper. With this simple construction, described here, the danger of makeshift rollways slipping under load has been eliminated with a decrease in accidents to the men and the rolls of paper. Although these rollways fit into angle-iron slides on the side of the truck they can as easily be hooked on the end.



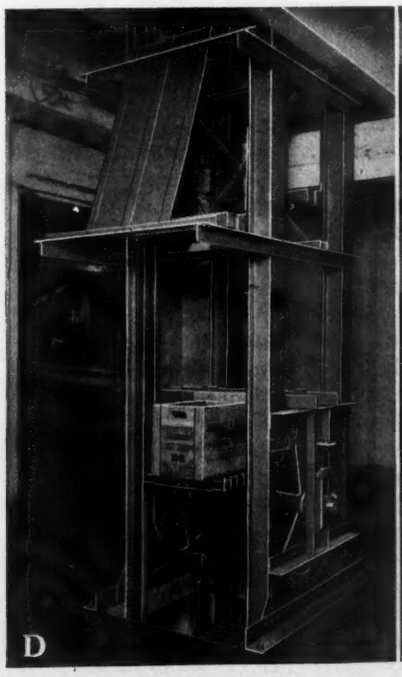
The general arrangement for bottling mineral water.

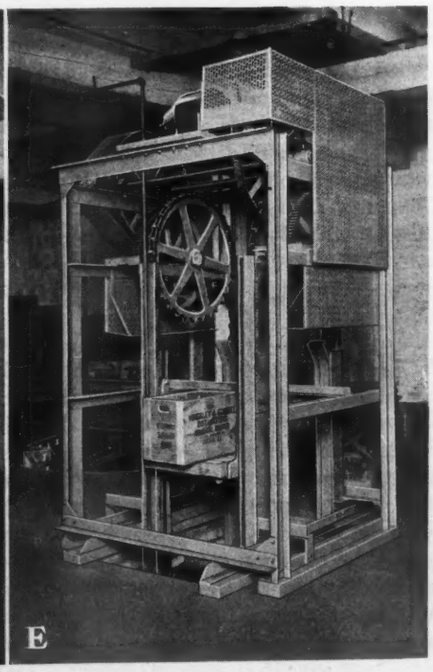
A. Empty bottles and cases are elevated to the top floor on the vertical conveyor shown in *D* and *E*, are sent through the washing and rinsing machines, shown in the distant background, labeled, and carried by a belt conveyor through the automatic filling machine. The bottles are put in cases and carried over the "boosting" section of the roller gravity conveyor to the spiral conveyor whose opening is shown in *B*. This spiral extends to the first floor, *C*, where the bottles are loaded on hand trucks and placed conveniently for loading on delivery trucks to be delivered to the customers.

is in the distant background in *A* at the right, but cannot be seen in the illustration. A man takes the bottles from the case, puts them in the washer and sends the empty case, still on the roller conveyor, past the bottling machine to be filled. The empty bottles go through the washer, are moved by hand over to the rinsing machine, the label is attached, and the empty but clean bottles are set upright on the rubber belt which carries them to the automatic bottle-filling machine. By placing the label on the bottle when empty it is not necessary to handle a half gallon or gallon of water in addition to the bottle. This one scheme alone eliminates the hand lifting of tons of water each day.

Each bottle is placed automatically in the machine by the belt conveyor, filled, again placed on the belt, the top sealed by hand and the bottle is then ready to be placed in the case. A row of filled bottles on this belt conveyor is shown in the background of *A* with two men putting on seals. The empty cases coming from the bottle washer rest on the roller conveyor shown in *A* alongside the two men and the row of bottles. The men lift the bottles from the narrow belt conveyor and place them in the cases on the roller conveyor.

A case holds a dozen half-gallon or six gallon bottles. The filled cases then make the loop shown at the left in *A*, go up to the elevating or booster section shown just behind the pillar and around to the right on the conveyor line, which is again shown along the wall in *B* and terminates in the spiral roller conveyor which extends the full four floors down. The lower end of this spiral is shown at *C* where the cases are





Cases of empty bottles are raised to the fourth floor by this equipment.

Cases are loaded by hand at *D* and automatically discharged on the fourth floor at *E* (see also *B*) onto a roller gravity conveyor which carries them to the washing machine. The General Electric motor operating this vertical conveyor is under Cutler-Hammer pushbutton control of the loader on the first floor and the operator of the bottle washer on the top floor. This lift will handle about 10 cases per min. They are lowered to the first floor by gravity.

loaded on lift-truck skids or on four-wheeled trucks to be placed on the loading platform convenient for transferring to trucks or wagons for delivery.

At present, due to the greatly increased capacity of the plant, the same gang that fills the bottles at the top is used to empty the spiral conveyor at the bottom. Previously the men could hardly keep up with the demand. Now at any time the output can be increased by adding men at the bottom of the spiral, a provision which could almost double the present output if necessary by making the filling process continuous instead of operating about half the time. The spiral conveyor provides an additional storage space as it holds between 200 and 250 cases and can be left filled in addition to the skids of filled cases on the loading platform.

The automatic lift shown in *D* and *E* is operated by Cutler-Hammer pushbutton control by the operator who loads it on the first floor, or by the man at the bottle washing machine on the fourth floor. The lift has a capacity of approximately 10 cases per min., which is faster than the bottles can be taken care of by the bottle washer. As a result, when the conveyor line between the lift and the bottle washing machine is filled the elevator is shut off. The belt conveyor at the filling machines, this lift, and two boosters, one of which is shown in *A*, to raise the cases to a higher level, are the only power driven elements in the conveyor system. These are operated by General Electric direct current, 110-volt motors; the rest of the conveyor system does not use power because it is operated by gravity.

The filling of the 5-gal. bottles for office coolers is also speeded up by a short roller conveyor system. Each 5-gal. bottle is handled in an individual crate which protects it during delivery and in storage. As the bottles are received from customers they are piled on hand trucks on their sides with the necks of the bottles projecting out. A truck is pushed to the bottle washer, the operator removes the bottles from the crates and inserts them in the washer. The empty crates are put on a short roller conveyor system which carries them to the back of the machine where another operator removes the washed and rinsed bottles and places them again in the crates which are carried on by the conveyor to be filled, stoppered and piled on trucks or skids ready for loading and delivery.

Approximately ten million gallons of water are handled yearly, which would amount to over 275 tons a day if assumed to be evenly distributed over 300 working days. With the addition of this conveyor system the capacity has been practically doubled and the plant is now able to take care of a large increase in demand at a much less expense for conveyor than to provide increased floor space and more men.

The rubber belt conveyor was installed by the U. S. Bottlers Machinery Company, Chicago, as a part of the automatic filling equipment, while the roller gravity conveyor system was put in by The Dow Company, Louisville, Ky.

Where a magnet beats hand picking and sorting of refuse.

If this work was done by hand it would not only take longer, but many of the small pieces of iron would be lost and also some refuse would not get separated. All non-magnetic refuse is discharged through the floor into a dump car and hauled away.

Magnetic Separator Reclaims More Iron With Less Work in Foundry

MOST foundries, because molding from the receipt of the pig, sand, coke, and so on, to the shipping of the finished casting is largely handling and rehandling, offer many opportunities for simplifying and decreasing the labor incidental to the numerous operations involved. One of these lies in the separation and reclamation of iron from screenings and foundry refuse. At the Spring City Foundry, Waukesha, Wis., this waste is put through the Dings magnetic separator shown in the accompanying illustration. Ordinarily 2½ tons of refuse are handled daily and from this about 500 lbs. of iron per ton is reclaimed. It takes a man about five hours a day to gather this refuse from the floor and take it about 150 feet in wheelbarrows to the separator. The wheelbarrows are dumped into a skip which is lifted by a compressed air hoist and discharges into the revolving separator, as shown in the illustration. The sand goes through the screen into a dump car on the floor below. The iron is picked up by a semi-circular magnet which fits around approximately half of the solid steel shell or drum at the discharge end of the screen, as pointed out by the two arrows. This magnet holds the iron against the side of the revolving drum and carries it to the top where the semi-circular magnet ends. The iron then falls into the discharge chute. Bricks, cores, or other large pieces of refuse which are not attracted by the magnet are rotated on out of this steel drum through a separate discharge to the floor below so that, if desired, they may be kept out of the fine screenings.

This not only simplifies the handling, but, like many other mechanical substitutions for hand operations, increases the effectiveness of the operation—in this case a greater percentage of metal is reclaimed. Direct current for the operation of the magnet is provided by a separate generator set on top of the magnetic separator. The Dings Magnetic Separator Company, Milwaukee, Wis., installed this equipment.

Decreasing Production Interruptions

(*Continued from page* 474)

a momentary starting current of approximately 250 amp. These motors are served in groups of from six to eight, with a branch feeder and breaker for each group. Wall space was limited, and it was necessary to place the breakers in two horizontal rows, one above the other.

To take care of this condition, the cabinet shown in Fig. 3 was designed. The two feeders which serve this floor, consisting of 750,000 circ. mil varnished-cambric and flame-proof-braid-insulated cables (two for positive and two for negative in each feeder), each in a separate pipe, enter the shallow part of the cabinet from below at the right-hand side. Here they are attached to the distributing bus by lugs as shown, one feeder serving the upper row of breakers and the other the lower. All breaker connections are made with bar copper. When all the breakers have been installed and connections are complete, the two cabinet fronts, with a substantial hinged door before each breaker, are put in place. The fact that a riser for the floors above in the same building had to pass at the point where the cabinet was installed made the design of the cabinet slightly more difficult, as it was necessary to allow space behind it for the passage of the four pipes carrying this riser.

This cabinet, while apparently a rather expensive piece of equipment, was, in fact, less costly than the number of standard individual breaker cabinets which it supplants. It was built locally by a contractor and the copper bar work was all done by the electrical force in the plant.

Branch feeder cables leave the cabinets in most cases at the bottom, dropping through the floor and running on the ceiling below, with taps up to the motor circuit breakers to be served. As many motors as convenient are connected to each branch feeder, the largest feeder having a capacity of 600 amp. No protective device is installed directly at the point where the taps leave the feeders but each motor has its own circuit breaker mounted near the motor. Before running taps in this way without a cut-out at the feeder connection it was necessary to obtain special permission from the local Underwriters' Fire Inspection Bureau. As these taps are protected only by the branch-feeder circuit breakers they should be the same size as the feeders according to the code ruling. However, the permission was obtained to run taps of motor-size cable of not greater length than 15-ft. without the installation of cut-outs, provided no wire smaller than No. 4 were used in the taps. This permission the Bureau was glad to give, in view of the high class of construction that was being done and the safeguards applied.

Breakdown of Electrical Equipment

(*Continued from page* 491)

service may be it is hopeless for us to try to accomplish anything in the way of reduction of accidents unless we obtain this close co-operation with the assured and his employees. Our policy coverage is so extremely broad that any deliberate or misguided act on the part of any man in the plant might easily do a large amount of damage to the equipment we are insuring. The moral hazard of the risk, as explained above, is the really important thing and is given by far the most important place in our underwriting consideration of the risk. Other points brought out by our inspector's survey are also given due consideration.

One feature of our engineering service which is being given much thought and consideration is the relation between safety measures for the protection of life and limb and safety measures for the protection of the machines. We are convinced that these go hand in hand, and anything which we can do in any industrial works or power plant to improve the conditions under which the machines are operated and to make conditions safer for the operators will be a big step toward cutting down the number of losses to the machines. When we put guards around motors and generators, this not only prevents the employees from getting their hands on live wires or getting caught in the machinery, but at the same time prevents any such action on their part from short-circuiting the winding or breaking the machine. Signs are placed around the plant not only to warn the operators and public of live wires, but also to prevent a serious accident due to someone touching the wires and causing a short circuit which would set up a surge on the line and possibly burn out two or three pieces of equipment.

Mr. Nickel's Installation on Page 363 of August Issue

THE photographs from E. C. Nickel, Cal., on page 363 of the August issue of the INDUSTRIAL ENGINEER, certainly show very neat work and no doubt everything works just as nice as the photographs look. It is customary, especially in large motor installations, to arrange all of the devices as compactly as possible in order to avoid the use of exceptionally large wires. If, as stated, the motor is on the floor below (not the ceiling) there is considerable conductor run from the controller, resistance, etc., to the motor, and while this does not matter so much as far as the stator circuits are concerned, unnecessary resistance is introduced in the rotor circuits which is important when the controller is in the running position and when it is desired to have the rotor resistance as low as possible. When starting, the extra resistance does not have any detrimental effect, since resistance starting is used anyway and a little extra resistance can do no harm. If the extra resistance is too much, however, the starting torque will be reduced, since the proper relation between resistance and reactance will not exist for maximum torque at standstill.

In cases where considerable distance between motor and controller, etc., is necessary, remote control either mechanical or electrical is used, as the saving in copper, due to short runs, as well as the improved operating conditions, more than pays for the additional apparatus which is necessary.

The starting resistance is apparently mounted in front of a wooden post which is, no doubt, protected and for some reason the ground wire from one of the supporting brackets hangs loose. I think the relative positions of the circuit breaker, controller and resistance are good, since all are in plain sight and readily accessible. The resistance, as arranged, has exceptionally good ventilation and is substantially mounted.

Mr. Nickel has considered all of these points and has, no doubt, ar-

ranged everything as he thinks best. If he gets good results, which no doubt he must, then all comments are of not much avail.

The conduit arrangement to the switchboard looks good to me and I can therefore offer no comment other than to praise it. Of course, in making conduit runs I would avoid all bends possible, especially right-angle and more acute bends. This is not so important, however, in cases where there is plenty of room in the conduit for the conductors, since they can be drawn in easily and do not cramp one another. Conduits, even though mechanically strong, require considerable care in their installation in order to avoid damaging and grounding the conductors. It is very surprising to see how frequently conductors in conduit systems are accidentally grounded, especially in flexible metallic conduits. No one wants accidental grounds, as they are troublesome and hazardous. Only purposely made grounds are desirable.

Patchogue, N. Y. HENRY MULFORD.

Trade Literature
You Should Know About

Thwing Instrument Company, 3339 Lancaster Avenue, Philadelphia, Pa.—Bulletin 11 on "Thwing Radiation Pyrometers" gives construction and operation details of indicating and multiple-recording types. Radiation type thermometers are made to cover the temperatures between 925 and 5,000 deg. F.

The Chisholm-Moore Manufacturing Company, Cleveland, Ohio—Catalog 26 lists the "Cyclone" high-speed chain hoists of ¼ to 40-ton capacity and the trolleys and hand-power traveling cranes manufactured by this company. A large number of the 88 pages are devoted to illustrations of numerous installations in various industries.

Edison Lamp Works of General Electric Company, Harrison, N. J.—Bulletin L. D. 102-A, entitled "Effect of Color of Walls and Ceilings on Resultant Illuminations," includes a chart giving the reflection factors for light from Mazda lamps on various ceiling and side wall tints and papers, as well as wood finishes. Samples showing the actual colors are tipped into the chart.

DeLaval Steam Turbine Company, Trenton, N. J.—Catalog C covers a new line of velocity steam turbines especially designed for high-pressure and high-temperature steam. The turbines are built in sizes up to 1,200 hp. and are designed to be directly coupled to high-speed centrifugal pumps and blowers, small alternating and direct current generators and, by means of double-helical speed-reducing gears, to large pumps and blowers, medium-size generators, belt pulleys, rope sheaves and slow- and moderate-speed machinery.

Joseph Weidenhoff, 4352-8 Roosevelt Road, Chicago, Ill.—The use of the Weidenhoff armature fault-finder is described in bulletin No. 982 recently issued. One interesting feature is a diagram method of recording the faults of an armature. This fault-finder can be used on testing starting motor armatures as well as generator armatures.

Link-Belt Company, 910 South Michigan Avenue, Chicago, Ill.—Book 444 describes the "Power Hoe" and its use in the storage and reclamation of coal in yard storage.

Arex Company, Conway Building, Chicago, Ill.—A group of bulletins describes the Arex natural draft ventilators and illustrates their use in numerous industrial works.

National Metal Molding Company, Pittsburgh, Pa.—Catalog No. 250 lists the various "National" outlet boxes and covers, concrete boxes, switch boxes, cast cable boxes, and other miscellaneous items manufactured and distributed. In this catalog boxes of a type are grouped together, square covers together, round covers together, and so on to facilitate consultation and reference.

B. F. Sturtevant Company, Hyde Park, Boston, Mass.—Catalog No. 291, a 72-page bulletin on "Pneumatic Collecting and Conveying Systems" contains 33 pages of pictures and diagrams, 17 pages of useful tables showing, for example, how to find the size of fans, the suction, volume, r.p.m. and horsepower for any system, cubic feet of air handled per minute, size of pipe and ducts used, and so on. Data is also given on dust collecting, the removal of fumes, gases, and so on with a discussion on the conveying of pulverized coal, fibrous materials, coffee, ashes, wool, wood chips and other loose materials. A copy will be sent on request.

Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.—A new publication on Micarta gears, folder No. 4453, entitled "Quiet Running Gears," enumerates the points of superiority claimed for Micarta gears, such as quietness, durability and efficiency, and shows the advantages claimed to be derived from the use of Micarta in place of other non-metallic gears.

The Texas Company, 17 Battery Place, New York City—The August issue of "Lubrication," published monthly, goes into considerable detail on the selection and use of lubricants for the various types of elevators, each of which is described and illustrated. Distribution is free to those in responsible positions in industry.

The Cutter Company, Philadelphia, Pa.—A 98-page bound booklet entitled "Protection Up to Date," contains many interesting points in regard to the U-Re-Lite circuit breaker and shows numerous installations of this type of equipment. Every man responsible for maintenance will want one of these in his library.

General Electric Company, Schenectady, N. Y.—Bulletin No. 48,028 devotes 60 pages to a description of various types of electrically operated pumps, with installations illustrated, and gives motor recommendations and other technical data for each type.

Buffalo Forge Company, Buffalo, N. Y.—Catalog No. 700 contains valuable tables and other data on the Buffalo fan system of heating, ventilating and humidifying. In all, 115 pages are devoted to the explanation of the principles involved in this work and the tabular data required to make heating, ventilating and humidifying calculations.

Schutte & Koerting Company, Philadelphia, Pa.—A new catalog, consisting of three illustrated bulletins, describes mechanical fuel-oil burning systems and fuel-oil burners in which the oil is atomized by low or high pressure air and steam. It discusses thoroughly the installation, operation and maintenance of oil-burning equipment, its characteristics, requirements and functions, the relative merits of mechanical and spray oil burners, etc. The catalog contains over 25 tables.

Zobell Electric Motor Corporation, Garwood, N. J.—Bulletin 100, recently issued, describes the line of Zobell Type H, direct-current motors, which are made in five frame sizes rated from 1 to 5 hp. at 1,750 r.p.m. Besides giving a detailed description of the bearings, windings, lubrication, and other construction and operating features, two curves show characteristics of shunt-wound motors for general purpose service and series-wound motors for crane and hoist service.

A bulletin will be issued shortly descriptive of their Type C, polyphase, squirrel-cage and slip-ring motors. These are interchangeable as to rating and essential over-all dimensions with the direct-current motors.

Carr Fastener Company, Boston 39, Mass.—A circular describes the use of the "Dot" high pressure lubricator in the care of industrial machinery by positive lubrication.